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COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. XIII JANUARY, 1908 No. 1

AIR COMPRESSORS ON NEW YORK TUNNEL WORK

By Frank Richards.

The tunnel stage of the development of New York city may be said to have really commenced with the present century. Although the first tunnel under the North River was planned and begun a quarter of a century ago, it has only lately been completed with also its twin tunnel for the reciprocal traffic. On account of the earlier completion of connections, other tunnels begun within the present century will be in established service before these.

The tunnels completed or approaching completion, including the two mentioned above, are as follows:

Six tunnels under the North River; the two from Morton street, Manhattan, to Hoboken to be used for trolley car service; two near Cortlandt street and two about Thirty-third street for the Pennsylvania Railroad, and eight under the East River; two from the Battery up into the heart of Brooklyn, as a continuation of the already completed Subway; four to connect the Pennsylvania Railroad with the Long Island Railroad, two of these tunnels also extending all across Manhattan; and the two so-called Belmont tunnels which are

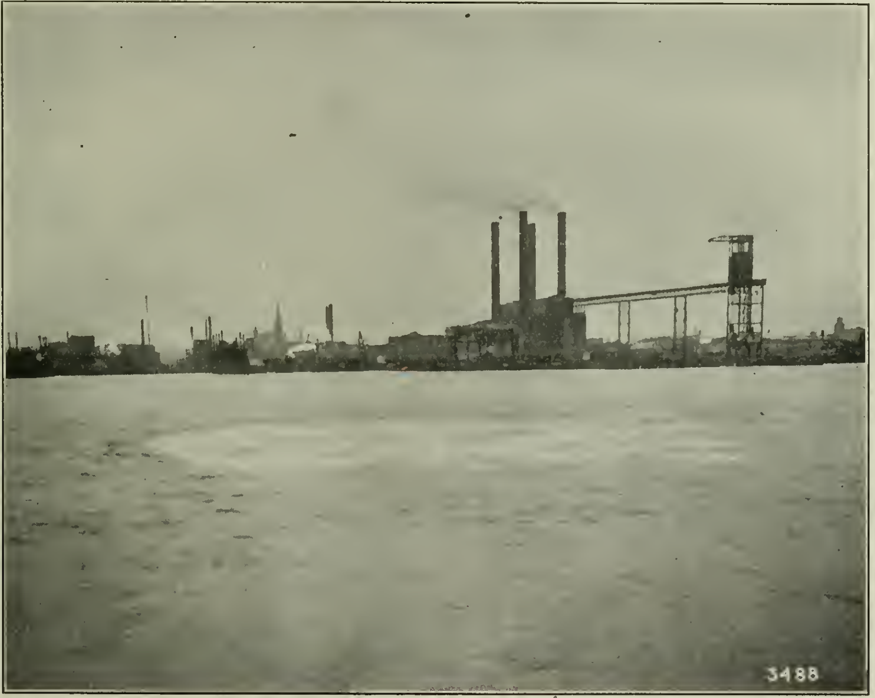


Fig. 12. Escape of Compressed Air from Tunnel Working.

to connect the Forty-second street line of the present Subway with Long Island trolley lines.

This tunnel work involves not only the actual driving of the tunnels under the rivers as indicated, but greater additional lengths of subterranean tunneling for the approaches or connections. Other tunnels "too numerous to mention" in these and other directions are planned and more or less specifically provided for to supply work for at least twenty years ahead, by which time the tunnel habit will have become so established that no one now can suggest the amount of subterranean and subaqueous excavation and construction which will ultimately be required in New York and vicinity.

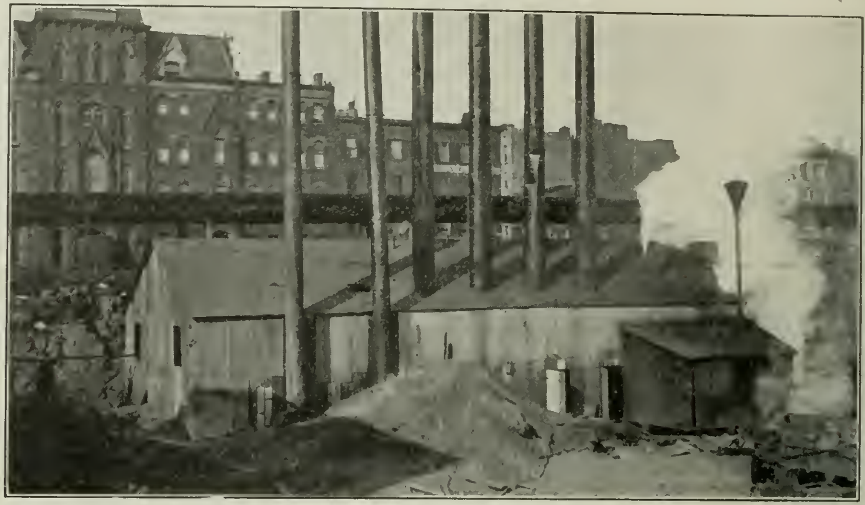


Fig. 1. Temporary Power House, Pennsylvania Terminal.

We have here to do with only one, although the most important, physical agency in all this tunnel work, the compressed air supply. Merely to enumerate the air compressing plants which have been installed in New York for tunnel work alone, with mention of a few of their most important details, is enough for the present paper.

It will be noted that all the air compressors herein enumerated are New York machines, machines largely developed by New York practice in the building of the Aqueduct, supplemented by mine and tunnel work throughout the world, and perfected and manufactured by the two New York companies of world-wide reputation in this line, the Ingersoll-Sergeant and the Rand, now in the natural course of business events combined in a single concern, the Ingersoll-Rand Company. The position of this company in this great metropolitan

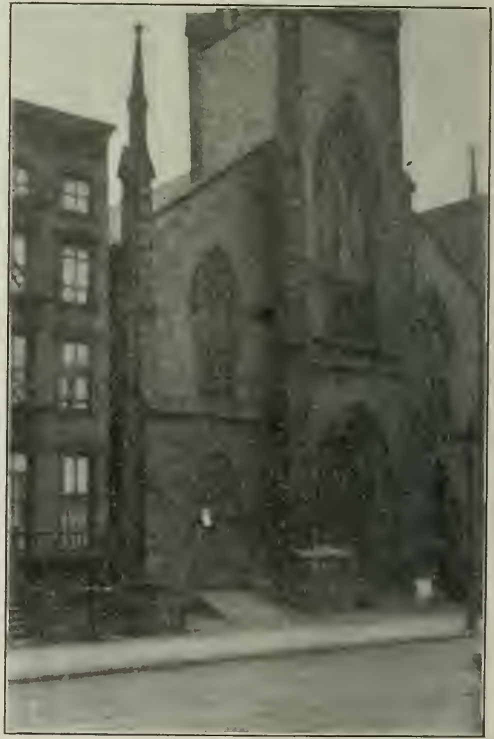


Fig. 2. Power House, Pennsylvania Terminal.

development is unique, and cannot be approached for parallel or comparison in any other line of business.

That there is plenty of tunnel work ahead for the air compressor might well be inferred from the substantial and apparently permanent character of many of the installations. Several of the plants here mentioned will undoubtedly be employed to supply the air for other tunnels besides those for which they have been originally erected. These plants accordingly have generally nothing cheap or temporary about them. They employ all the usual well-known devices of economy both in the use of steam and in the compression of the air. The boilers are all of modern design and nearly all of the water tube type. The steam units are usually compound and condensing, and the air compression two stage with intercoolers and aftercoolers. Gravity oiling systems are installed, which constantly and perfectly lubricate every part and return the oil for repeated use. The action of the compressors is regulated automatically according to the call for the air, so that a series of machines will run constantly without handling the throttle. Recording gages are generally employed and their records are watched and filed in the offices.

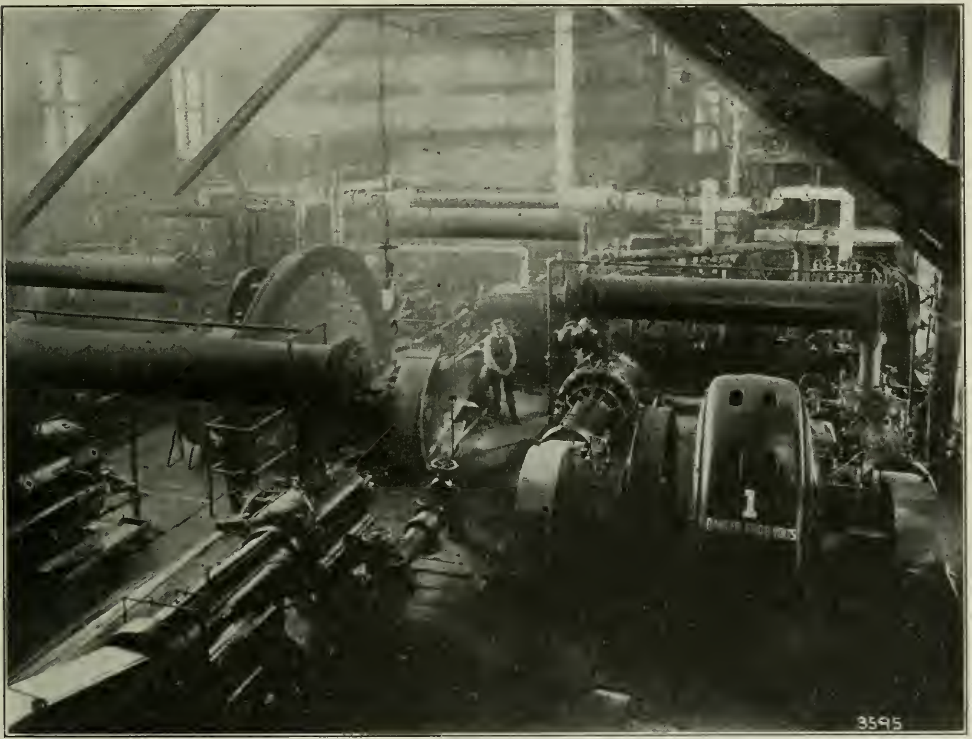


FIG. 3. INTERIOR PENNSYLVANIA TERMINAL POWER HOUSE.

While as a rule nothing has been neglected in the installation of those plants which could contribute to the reliability and economy of their operation, to the accessibility of parts and convenience of manipulation, so that, seen within and with all the circumstances considered, many of them may be taken as models of their class, but the slightest thought has been given to the exteriors of the buildings. One plant is located in an old church, another in a dilapidated foundry, and in several cases the compressors, boilers, etc., have been completely placed in the open air and their protective sheds or buildings have been erected over them.

The perfection and endurance of the compressors may be noted as remarkable. The writer hereof more than a year ago personally visited every plant mentioned except that upon

Man-o'-War Reef, the improvised island in the East River, and while most of the compressors seen were being worked to the limits of their capacity, running at speeds which were astonishing, not one was seen out of order or undergoing repairs. The arduous work on the New York aqueduct and in tunnels and mines everywhere has to a remarkable extent revealed and eliminated the weak spots and suggested successive improvements.

HIGH SPEEDS.

As indicating the speeds at which these compressors may be run, it may be specially noted that five duplex Corliss compressors, 42-inch stroke, in the Manhattan plant of S. Pearson & Son, Inc., were designed and guaranteed to run continuously at 100 R. P. M., or 700 feet piston speed, with a further provision that in case of emergency they would be capable of running at 125 R. P. M. for a period not exceeding twenty-four hours. This emergency has been encountered several times since the plant was installed, and in fact the machines have run as high as 135 R. P. M., or 945 feet piston speed, for long periods without apparent distress.

In the estimated free air capacities given herein for each plant the piston speed assumed for all is 500 feet per minute. The ¼-inch additional to the nominal diameters of the Ingersoll air cylinders is dropped out of the computations, as this normally compensates for the area of the piston inlet pipe, although in some of the compressors with mechanically operated valves this pipe is not used.

PENNSYLVANIA STATION EXCAVATION.

The work of excavating for the New York terminal of the Pennsylvania Railroad is not at all tunnel work, but it is at the point where four of the tunnels are to meet. This work was, to think of, a simple affair. It was only to dig a hole in the ground; but it was a hole measuring roughly, in the main portion of it, 1,800 by 480 feet and 40 feet deep, with more than a million and a half cubic yards of material to be removed. A considerable portion of the top was sand and gravel, which was removed first, but most of the material is solid rock. Both steam and compressed air are employed on the work. The steam shovels, being self-contained, also some traveling derricks and of course all of the locomotives, are steam operated, while rock drills, pumps, many hoists, concrete mixers, etc., are driven by compressed air, and here, as elsewhere, the compressors are driven to their full capacity.

A temporary compressor plant was first installed right upon a portion of the ground to be excavated, the exterior of the plant being shown in Fig. 1. The church and appurtenances in the background have since been pulled down and rock cutting is proceeding upon the site. There were here three Rand straight-line, Class "C" compressors with cylinders 24 and 26 inch diameter by 30 inch stroke, free air capacity 5,529 cu. ft. per min.,

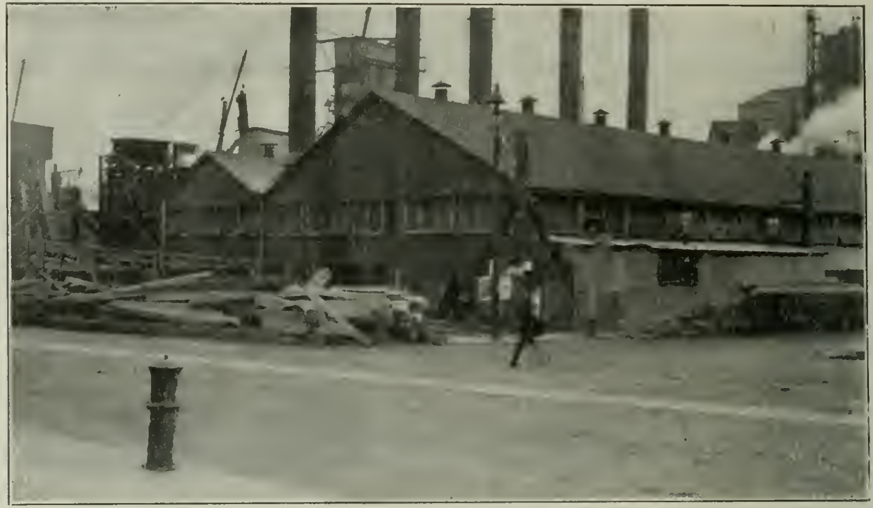


FIG. 4. MANHATTAN POWER HOUSE. S. PEARSON & SON.

and one Ingersoll Class "A," piston inlet compressor 24 and 26¼ by 30 inch stroke, free air capacity 1,843 cu. ft. per min. The steam cylinders had balanced valves and Meyer adjustable cut-offs and worked non-condensing. The steam pressure carried was 110 pounds and the air pressure 90 pounds, the latter not being always maintained, as the air was used as fast as it could be delivered. The rock drilling, however, was kept constantly in advance of the work of removal and many holes were always waiting to be fired when needed. The air was not cooled except by the water jacket. There were two large air receivers and a combined delivery pipe 8 inches diameter with valves for disconnecting each compressor. The air line was carried around the excavation with distributing branches where required. There were six locomotive boilers burning small anthracite. A Cochrane feed water heater was in service and two duplex steam pumps for boiler feeding.

It was well to mention this plant first, since it was, with perhaps one exception, the least economical of any of the plants here enumerated. Fig. 2 shows the exterior and Fig. 3 the interior of the more permanent installation of the New York Constructing Company for this Pennsylvania Terminal excavation. This is a plant of much larger capacity and doing its work more cheaply. The building, as is evident, was a church, but the interior is now as unecclesiastical as could well be imagined.

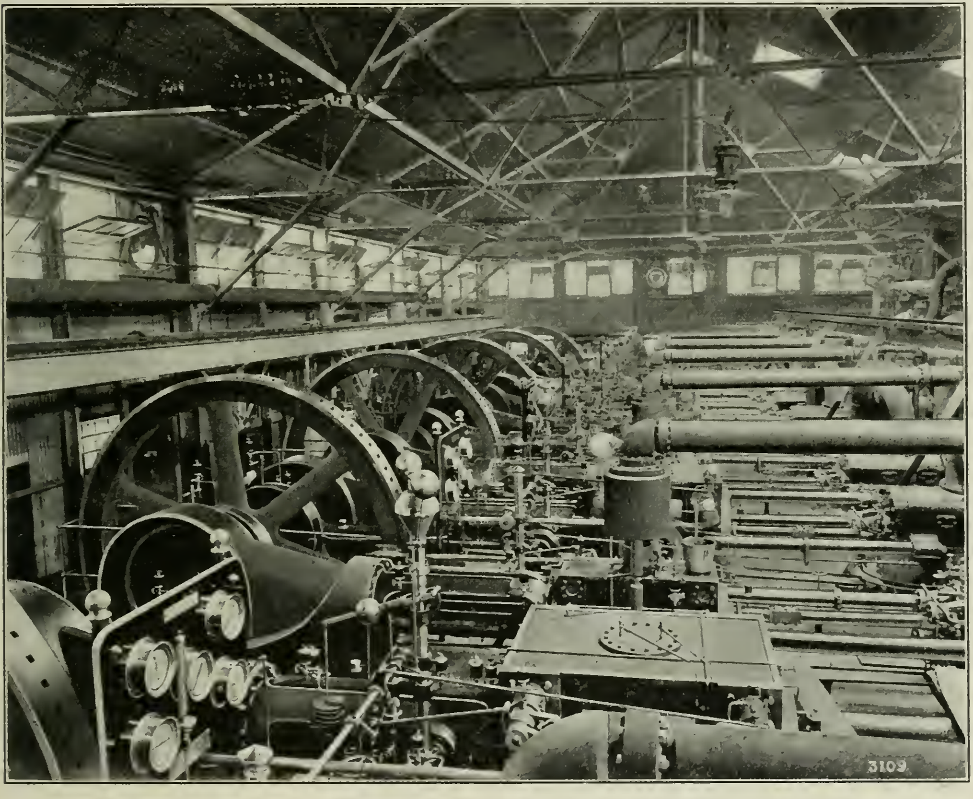


FIG. 5. INTERIOR S. PEARSON & SON'S MANHATTAN POWER HOUSE.

There are here three two-stage, electric-driven R. D. 2 compressors with air cylinders 30 and 19 inch diameter by 30 inch stroke; free air capacity, 8,983 cu. ft. per min. The induction motors are each 500 h. p. General Electric, Type LM, 122 revolutions per min., 6,600 volts, 3 phase, 25 cycle. There is also one Rand Corliss, cross compound, I girder frame, two-stage compressor with steam cylinders 22 and 40 and air cylinders 38 and 23 by 48 inch stroke; free air capacity, 3,937 cu.

ft. per min. In addition to these are the four compressors of the temporary plant previously enumerated and therefore here not mentioned further and not repeated in our final summary of the various plants.

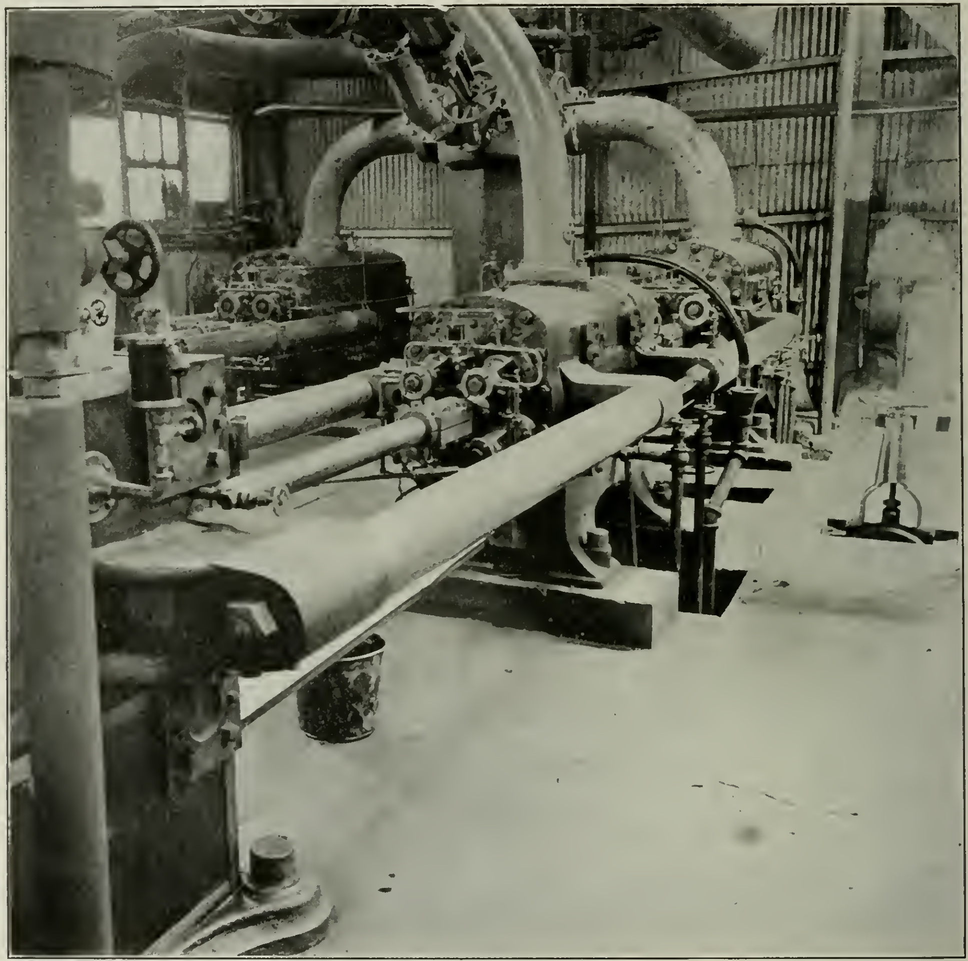


Fig. 6. Tandem Air Cylinders on Special Compressor.

PENNSYLVANIA RAILROAD EAST RIVER TUNNELS MANHATTAN PLANT.

The plant of the contractors, S. Pearson & Son, Inc., at Thirty-third street and First avenue, New York, is in marked contrast to the preceding. Fig. 4 is a snapshot of the exterior and Fig. 5 shows the interior. The entire equipment in this case was installed under the direction of the builders of the compressors, the Ingersoll-Rand Company. There are four cross compound Corliss compressors with steam cylinders 16 and 34 by 42 inch stroke, with duplex air cylinders 26¼ inch for a maximum air pressure of 50 pounds; free air capacity, 14,744 cu. ft. per min. There is another cross compound Corliss compressor of the same stroke and with the same cylinder dimensions as the above, but with duplex air cylinders 15½ inch diameter designed to compress to 140 pounds air pressure. The air for this compressor may be taken into the cylinders at the atmospheric pressure or it may be taken in at 40 or 50 pounds pressure from the aftercooler of the low pressure service, thus increasing its delivery at the high pressure about fourfold. Free air capacity, 1,310 cu. ft. per min. Another compressor has a special combination feature. It is a cross compound Corliss compressor with the same cylinder dimensions as above, but with tandem air cylinders 23¼ and 15½ daimeter on each side. These cylinders on one side are seen in Fig. 6. All the air cylinders may be used to compress atmospheric air to 50 pounds pressure and deliver individually into the low pressure service or by disconnecting the 23¼ inch cylinders the smaller cylinders may be used for the high pressure service, 140 pounds, precisely the same as the preceding machine. Free air capacity of this compressor, 4,194 cu. ft. per min. Besides these there are two straight-line, Class "A" compressors 18 and 18¼ by 24 inch stroke, used for preliminary development work and generally held in reserve. Free air capacity, 1,766 cu. ft. per min. This is the plant mentioned above guaranteed to work up to a piston speed of 700 and in emergencies to 875 feet per minute, and which has been run up to 945 feet in actual work.

There are here six 500 h. p. Sterling boilers, three Wheeler condensers, with independent Edwards air pumps, three centrifugal pumps of the Buffalo Forge Company supplying water from the East River for jackets, intercoolers, aftercoolers and condensers, duplex boiler feed pumps in duplicate, a separate system of gravity lubrication, a special loop steam system with Holly drip arrangement and a chemical oil separator. A working steam pressure of 150 pounds is carried throughout and everything possible is run condensing except what is required for heating the feed water. The power house contains three high speed engines with direct connected generators and three duplex high pressure hydraulic pumps automatically controlled to supply water for advancing the shields, with which we here have nothing to do. Total free air capacity of plant, 22,014 cu. ft. per min.

PENNSYLVANIA RAILROAD EAST RIVER TUNNELS LONG ISLAND CITY PLANT.

This plant of S. Pearson & Son at Flushing street and East River has the same units as the above, except that it has no Class "A" compressors, and the entire plant is quite differently arranged, the large yard space allowing great length for the power house. Fig. 7 is a snap-shot of the exterior. The vertical pipes will be noticed, capped with strainers for the intake air. Instead of the Class "A" compressors an additional Corliss compressor, the same as the others for low pressure air, was installed, making the total free air capacity of the plant at 500 feet piston speed—23,934 cubic feet per minute.

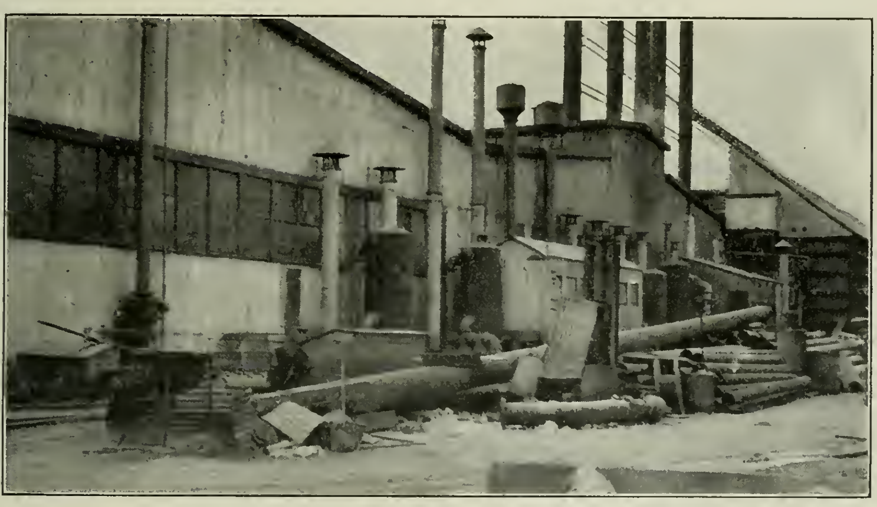


FIG. 7. LONG ISLAND CITY PLANT. S. PEARSON & SON.

PENNSYLVANIA RAILROAD NORTH RIVER TUNNELS, MANHATTAN PLANT.

The plant of the O'Rourke Engineering Construction Company at 33rd street and 11th avenue, New York, the general exterior of which is shown in Fig. 8, comprises three cross compound Corliss compressors with steam cylinders 14 and 30 by 36 inch stroke and duplex air cylinders 23¼ inch diameter for maximum air pressure 50 pounds. Free air capacity, 8652 cubic feet per minute. There is also one cross compound Corliss compressor with steam cylinders 14 and 22 by 36 inch stroke and duplex air cylinders 14¼ inch to compress to 140 pounds, using either free air or air taken from the aftercoolers of the low pressure compressors. Free air capacity, 1068 cubic feet per minute.

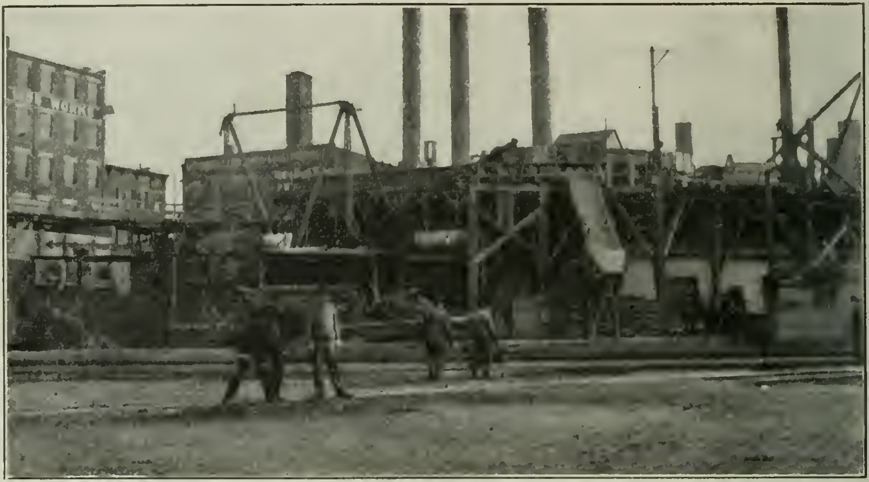


FIG. 8. MANHATTAN POWER HOUSE. O'ROURKE ENGINEERING CONSTRUCTION CO.

PENNSYLVANIA RAILROAD NORTH RIVER TUNNELS, WEEHAWKEN PLANT.

This plant, also of the O'Rourke Engineering Construction Company, foot of Baldwin avenue and North River, Weehawken, N. J., is an exact duplicate of the preceding. Total free air capacity, 9720 cubic feet per minute. The interior of this plant is seen in Fig. 9.

PENNSYLVANIA RAILROAD TUNNEL UNDER BERGEN HILL.

This plant of the John Shield's Construction Company at Hempstead, N. J., comprises one Ingersoll Class "A" compressor, 24 and 24¼ by 30 inch, free air capacity, 1570 cubic feet per minute, and four Rand Class "C" 24 and 24 by 30 inch, free air capacity, 6280 cubic feet per minute.

NEW YORK AND BROOKLYN SUBWAY TUNNEL, BATTERY PARK, MANHATTAN.

The principal compressor in this plant of the New York Tunnel Company, the contractors, is an Ingersoll cross compound Corliss, steam cylinders 24 and 44 inch diameter and 48 inch stroke with two-stage piston inlet air cylinders 36¼ and 22¼ inch diameter. The engine has its own air pump and condenser. Free air capacity, 3534 cubic feet per minute. This compressor was originally installed at Jerome Park Reservoir, where it was in service about six years. Besides this, there are two Ingersoll Class "A" compressors, 24 and 24¼ by 30 inch stroke, free air capacity 3140 cubic feet per minute. There are two Heine and two Hogan water tube boilers.

NEW YORK AND BROOKLYN SUBWAY TUNNEL, JOROLEMON AND FORMAN STREETS, BROOKLYN.

This plant, while of considerably larger total capacity than that at Battery Park, has for its largest unit the other Jerome Park Reservoir compressor, an Ingersoll cross compound Corliss with steam cylinders 24 and 44 inch diameter by 48 inch stroke and single stage, piston inlet, air cylinders 24¼ inch diameter. Free air capacity, 3140 cubic feet per minute. This compressor also has its own air pump and condenser. There are also two Ingersoll cross compound, Class "GC" compressors with steam cylinders 22 and 34 inch diameter by 24 inch stroke and single stage piston inlet air cylinders 30¼ and 28¼ inch diameter. The difference in the diameters of these cylinders is due to the exigencies of manufacture when the machines were required at very short notice. These compressors were not required to compress the air to above 25 or 30 pounds. Free air capacity, 9184 cubic feet per minute.

There is one Rand Class B-4 cross compound compressor with single-stage air compression, steam cylinders 20 and 32 inch diameter by 30 inch stroke and air cylinders 26 inch diameter. Free air capacity, 3686 cubic feet per minute. Two Ingersoll Class "A" straight-line piston inlet compressors 24-inch steam and 24¼-inch air by 30-inch stroke. Free air capacity, 3140 cubic feet per minute.

BELMONT EAST RIVER TUNNEL PLANTS.

As these were the subject of a previous article we here merely enumerate the sizes and capacities of the compressors employed. At 42nd street, Manhattan, there is in one power house a Rand cross compound Corliss two-stage air compressor with steam cylinders 24 and 40 by 48 inch stroke and air cylinders 39 and 24 inch; free air capacity, 4147 cubic feet per minute, and an Ingersoll cross compound Corliss two-stage compressor with steam cylinders 22 and 40 by 42 inch stroke, and air cylinders 38 and 24 inch; free air capacity, 3937 cubic feet per minute. In the other power house there are three Ingersoll cross compound steam, duplex air class "H" compressors with steam cylinders 15 and 28 by 16 inch stroke and air cylinders 20¼ inch diameter for a maximum pressure of 50 pounds; free air capacity 6540 cubic feet per minute. There is also an Ingersoll cross compound steam, two-stage air, Class HC compressor with steam cylinders and stroke as above, but with air cylinders 25¼ and 16¼ inch diameter for 100 pounds air pressure. Free air capacity 1704 cubic feet per minute. Fig. 10 shows one of those compressors being set up in place before the house was built over it.

On Man-o'-War's Reef there are three duplex Class "J" Ingersoll belted compressors with air cylinders 20¼ inch diameter by 18 inch stroke for 50 pounds pressure; aggregate free air capacity, 6540 cubic feet per minute; one electric belted two-stage machine for 100 pounds pressure with air cylinders 25¼ and 16¼ diameter by 18 inch stroke; free air capacity, 1704 cubic feet per minute., and two Ingersoll Class "A" straight line compressors, 24 inch diameter, steam, 26¼ diameter air by 30 inch stroke; free air capacity, 3686 cubic feet per minute.

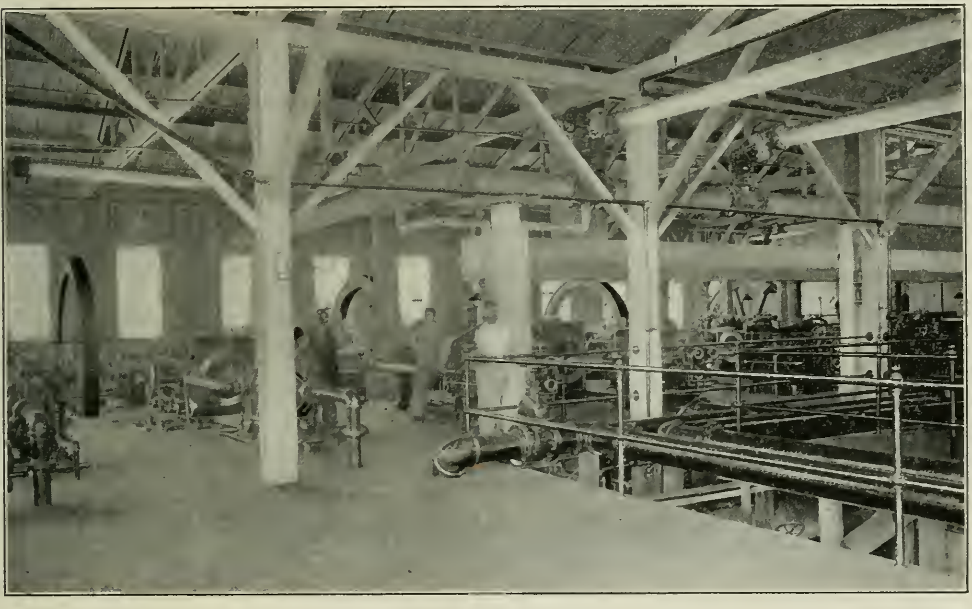


FIG. 9. INTERIOR WEEHAWKEN POWER HOUSE.

At the Long Island City plant there are two Ingersoll cross compound steam, two-stage air, Class "H" compressors with steam cylinders 15 and 28 by 16 inch stroke and air cylinders 25¼ and 16¼ for 100 pounds air pressure; free air capacity, 3408 cubic feet per minute. There are here also two Ingersoll Class "A" compressors 24 and 26¼ by 30 inch stroke; free air capacity, 3686 cubic feet per minute and one Class "A" compressor 24 and 24¼ by 30 inch stroke; free air capacity, 1570 cubic feet per minute.

HUDSON COMPANIES—NORTH RIVER TUNNELS, MORTON STREET, MANHATTAN.

This pair of tunnels now completed was begun, or one of them, a quarter of a century ago, the work having been stopped by serious accidents and financial difficulties. The final plant here comprised one duplex Rand compressor 22 and 22 by 24 inch stroke, free air capacity 2640 cubic feet per minute; one Ingersoll Class "A" 22 and 22¼ by 24, free air capacity 1320 cubic feet; one Ingersoll 20 and 22¼ by 24, free air 1320, and an Ingersoll 16 and 16¼ by 18, free air 698.

one Ingersoll duplex Class "H" compressor 16 and 20¼ by 16 inch stroke, free air 2178 cubic feet per minute.

HUDSON COMPANIES—NORTH RIVER TUNNELS, NEAR PENNSYLVANIA STATION, JERSEY CITY, N. J.

The tunnels here being driven are to enter New York City near Cortlandt street; there is no plant opposite, the tunnels being driven entirely from their western ends. There are here three Ingersoll Class "HC" cross compound steam, two-stage air, compressors for high pressure air, and three Ingersoll Class "H" cross compound steam and duplex single-stage air compressors for the low pressure air. The former are 14 and 28 inch steam and 24¼ and 14¼ air by 16 inch stroke, free air capacity, 4710 cubic feet per minute, and the latter are of the same steam dimensions with air cylinders 22¼ by 16 inch, free air capacity, 7920 cubic feet per minute.

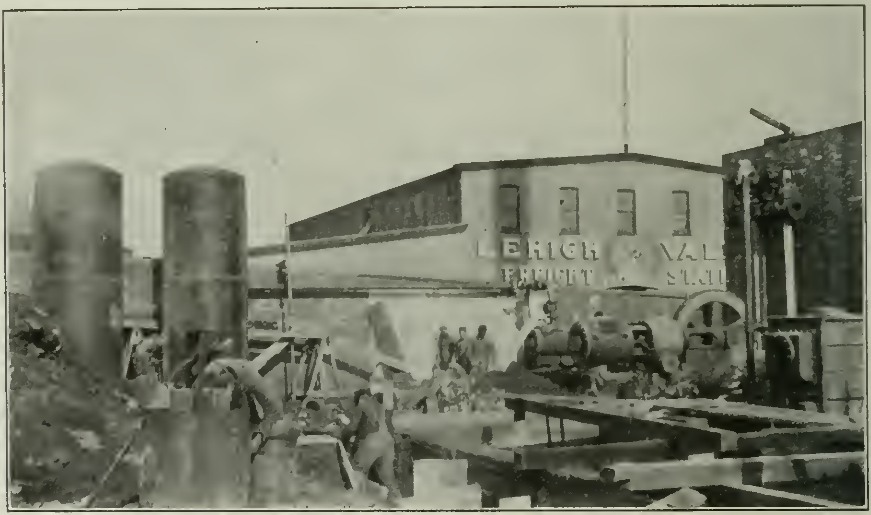


FIG. 10. ERECTING COMPRESSORS BEFORE THE BUILDING.

HUDSON COMPANIES—NORTH RIVER TUNNELS, 15TH STREET, HOBOKEN, N. J.

This plant is located immediately opposite the preceding, working at the other ends of the same tunnels and continuing them westward into the land. There is one compressor here which was sold to the Hudson River Tunnel Company in 1880 and overhauled in 1890 which was still doing good service until the work was finished. It is now rated as an Ingersoll Class "A", 20 and 20¼ by 30 inch stroke, free air capacity, 1089 cubic feet per minute. There are also two Ingersoll Class "A" compressors 22 and 26¼ by 24 inch free air capacity 2686 cubic feet per minute and

HUDSON COMPANIES—NO. 4 PLANT, WASHINGTON STREET, JERSEY CITY.

This plant has been employed upon land tunnels connecting the two preceding. It comprises two Rand Class "B" compressors, cross compound steam cylinders 18 and 30 inch, and two-stage air cylinders 26 and 15 inch by 30 inch, free air capacity 3686 cubic feet per minute, and two Rand Class "B" compressors with steam dimensions as above and duplex air cylinders 23 inch diameter by 30 inch stroke, free air capacity, 5768 cubic feet per minute.

SUMMARY OF TUNNEL PLANTS.

The total free air capacity of all the compressors here enumerated is 191,291 cubic feet per minute, which would be represented by a cube with a side of over 57 feet. The total number of compressors is 80, most of them approaching the largest sizes built. The actual horse power employed has not been computed on account of the differences in the air pressures, but probably was not less than 40,000. The number of steam cylinders is 120 and the number of air cylinders 138. That these compressors have been kept constantly running, mostly night and day, and generally at speeds which would be considered excessive, is something for the builders, the owners and the operators to be proud of. Whatever delays have occurred, whatever accidents have happened, whatever of the unforeseen has been encountered, the air compressors have been always ready, always efficient and always to be relied on.

It will be seen that the compressed air for this tunnel work is delivered and used at two quite different pressures, requiring two different classes of compressors and separate pipe lines for transmission. The low pressure air for the shield work is generally used at pressures between 20 and 30 pounds, the compression of this air is single-stage and the compressors are usually guaranteed for a maximum of 50 pounds. The high pressure air for operating the drills is required to be higher than the normal for such work, as the air from them is exhausted against the air pressure of the shield. The air for this service is carried at pressures above 100 pounds up to 140 or 150 pounds, the compression being two-stage with of course efficient intercooling. Many of the installations also include aftercoolers, which are found to contribute to economy of operation, giving drier air and reducing the volume during transmission without any ultimate reduction of volume when the air is used at the end of the line.

The usual conditions of steam economy are insisted upon throughout these plants. Steam is carried at pressures up to 150 pounds, the steam ends of the compressors are generally compounded, and condensing apparatus is usually installed for each entire plant whether the individual units are compounded or not. The automatic regulation of the speeds of the compressors according to the varying demands of the service has been a notable and successful feature.

Much the larger volume of the air compressed has been for the low pressure service to oppose the inrush of water, and passengers on the East River ferries have seen the water actively boiling with the escape of this air, so that most of it may in a way be said to have been lost or wasted. Under the most favorable conditions the use of air in subaqueous tunnels is a very different problem from that of the vertical caisson. In the latter the pressure adjusts itself precisely to that of the surrounding water, the air escaping under the edge when the pressure is at all in excess, and the compressor supplying a caisson has only to make up for the losses in the air lock and to renew the air sufficiently for safe respiration.

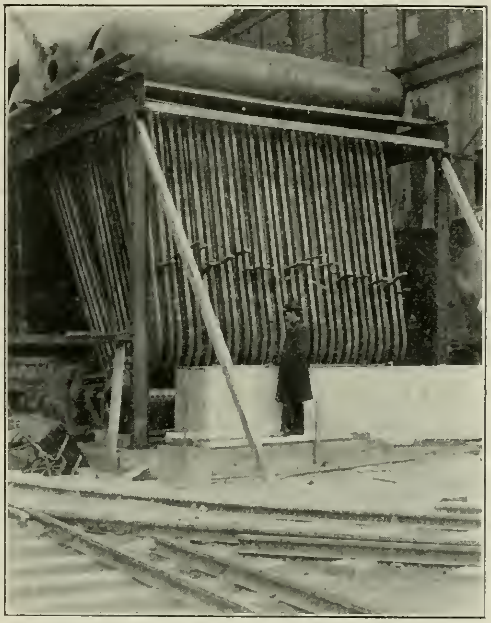


Fig. 11. Extending Boiler House.

When the air pressure at the top of the tunnel is sufficient to balance the pressure of the water and hold it back the air pressure at the bottom of the tunnel will be five or six pounds too light, and if the pressure is increased to balance the water pressure at the bottom then it is able to blow off at the top with considerable force, and where the superincumbent material is in a soft or semi-fluid condition the air finds its way through it in all directions. The compressors in this service were constantly worked to their utmost in the struggle with the soft mud waiting to rush in, and only a very unstable equilibrium could be maintained at the best.

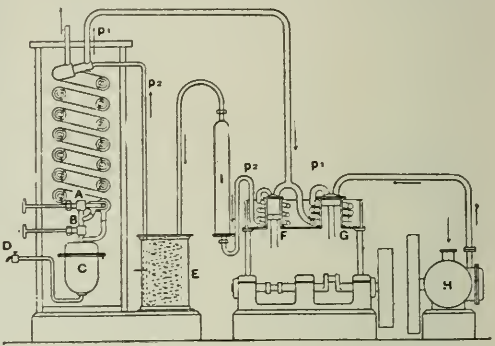
INDUSTRIAL LIQUEFACTION OF AIR

An extensive plant for producing oxygen from liquid air on an industrial scale is now being erected in Buffalo by the Linde Air Products Company, Dr. Linde's system of air liquefaction and subsequent rectification being applied. The following information concerning this interesting installation has been given to *Electrochemical and Metallurgical Industry* by Mr. Cecil Lightfoot, consulting engineer and general manager of the company:

The action of the Linde apparatus for producing liquid air is based on the refrigerating effect resulting from an expansion of air from a higher to a lower pressure and which is due to the performance of internal work. The action of any desired number of expansions is accumulated and intensified by causing each preceding expansion to act as a fore-cooler for the air for the following expansion. Since the refrigerating action depends upon the difference of pressure before and after expansion, while the work of compression corresponds to the ratio of these pressures, it is advantageous to select a large difference in pressures but a small ratio of pressures. In the Linde apparatus air is expanded from an initial pressure of about 200 atmospheres to about 50 or 20 atmospheres, so that the difference of the pressures varies between 150 and 180 and the ratio is between 4 and 10.

As will be seen in the cut, a triple coil is provided which is composed of copper tubes placed one within the other. This is called the heat interchanger. Air compressed to 200 atmospheres flows downward through the innermost coil, at the lower extremity of which it is allowed to expand to an intermediate pressure of 20 to 50 atmospheres. The expanded air is then returned through the annular space between the innermost and middle coils to the top, when it is again compressed up to 200 atmospheres pressure and the cycle is repeated. Immediately behind the first regulating valve A is placed a second valve B, through which, when the operation of the machine has been brought to a state of equilibrium, a small quantity of air is allowed to escape at atmospheric pressure, a corresponding amount being introduced into the cycle from the surrounding atmosphere. Part of this air leaves the second regulating valve in the liquid state and collects in the vessel C; the remaining portion is returned to the atmosphere through the annular space between the middle and outer coils. The liquid air is drawn from the collector by means of the small cock D.

In the larger installations the necessary compression of the air is effected by means of a high-pressure air pump, which is usually arranged for two-stage compression, working in conjunction with a single-cylinder low-pressure air pump. The high-pressure cylinder F of the former draws the partly expanded air from the heat interchanger at an intermediate pressure of about 50 atmospheres, and compressing it up to 200 atmospheres pressure, delivers it to the interchanger again through the cooler E. The air which is to be added to the cycle as "make-up" is supplied by the low-pressure air pump H, which draws it from the atmosphere, compresses it to a pressure of 4 atmospheres and delivers it to the low-pressure cylinder G of the high-pressure air pump, where it is compressed to a pressure of 50 atmospheres. At this pressure it enters the high-pressure cylinder, together with the partly expanded air from the heat interchanger, as described above.



Air Liquefying Apparatus.

Low-pressure compressors are not usually supplied with the smaller sizes of air-liquefying plants, the lower pressure of the cycle being in such cases maintained at 20 atmospheres and the low-pressure cylinder G drawing the "make-up" air direct from the atmosphere.

Regulation of the several pressures is performed with the aid of pressure gauges by means of regulating valves in the heat interchanger. Safety valves are provided to prevent the maximum pressures being exceeded.

In electric-furnace operations when electric energy is expensive, it is advantageous to preheat the charge or to start at once with a molten charge so as to produce only the highest temperatures from electrical energy, in order to save in the consumption of the expensive electrical energy. In the liquefaction of air where the object is to get a very low temperature it is advantageous in quite an analogous way to pre-cool the air. For this purpose a fore-cooler is provided by means of which the compressed air is reduced in temperature to 5 or 10 degrees above zero Fahrenheit, by refilling the receptacle provided for the purpose with a suitable freezing mixture, such as ice and salt. This is practical in smaller installations.

On the other hand, with large installations, the preliminary cooling of the air is preferably brought about by a small belt-driven refrigerating machine on the ammonia compression system. The adoption of fore-cooling is advisable in all cases, but especially when the cost of power is an item of great importance.

Between the compressor and the fore-cooler, apparatus is provided for separating water from the compressed air. This apparatus is provided with a suitable drain cock. Further extraction of the aqueous vapors from the compressed air with the smaller installations is performed in the fore-cooler. In larger plants the drying process is effected after the last stage of compression by means of chloride of calcium placed in the dryer supplied with the machine.

If the liquid air is to be used for the production of pure oxygen and pure nitrogen it is subjected to a process of rectification which is very similar to the process employed in spirit distilleries for the separation of alcohol and water. In this way it is possible to get oxygen 95 per cent. pure, and if the output is reduced by 10 or 20 per cent. the purity of the oxygen may be brought up to as much as 98 or 99 per cent. The chief advantages of this method of producing pure oxygen are claimed to be low expenses, simplicity and safety in work, and the freedom of the oxygen from water vapor, chlorine, etc. The residual gases entirely consist of the ordinary nitrogen constituents of the atmosphere.

An interesting application of nitrogen produced from air in this way is in the production of calcium cyanamide. Five Linde plants are already at work in Europe on a very extensive scale for this purpose alone, whilst other and still larger installations are now in course of construction, so that the industry appears to be already well established. It will be remembered that for the production of cyanamide, calcium carbide is treated in a nitrogen atmosphere at an elevated temperature. It is, therefore, necessary to first get the nitrogen from air. The question then comes up what to do with the oxygen, and while there are, of course, many applications like its use in blow-pipes, etc., the interesting suggestion has been made to use the oxygen for enriching atmosphere air in oxygen and then to treat the latter by electric arc discharges to produce nitrogen oxides for the subsequent manufacture of nitric acid and nitrates. In this way the two methods which have so far been found practical for the fixation of atmospheric nitrogen would work side by side; the nitrogen obtained from the liquid air would be used in the calcium cyanamide manufacture and the oxygen would be used in the nitric acid manufacture.

Altogether, about 100 liquid air plants on Dr. Linde's system have already been supplied, of which nearly half are employed either for the production of oxygen or of nitrogen in the pure state, or of both.

Liquid air at atmospheric pressure boils at 312 degrees Fahrenheit. As the more volatile nitrogen evaporates the color of the liquid assumes a bluish tinge, the color of liquid oxygen. Vacuum vessels are necessary for the storage of liquid air, oxygen and other gases which have these low boiling points. These vessels, generally cylindrical or globular, consist of two similar glass vessels but one considerably smaller than and contained in the other, the two being hermetically united at their necks. The space between the two vessels is then roughly exhausted and sealed under a high permanent vacuum. The rate of evaporation of liquid air in these vessels is approximately 5 to 15 per cent. of the original volume in 24 hours. As evaporation only takes place from the surface of the liquid, the size of the vessel is an important factor in determining the time the air can be stored. If allowed to rest in a quiescent state evaporation is much less rapid than if subject to vibration or larger movements. Vacuum vessels of half a gallon capacity and upwards should not be tilted to pour out the liquid, as the sudden cooling of the glass at the neck and the consequent local contraction might crack the vessel. A small hand pump is a convenient device for emptying vessels without tilting or inverting.

PORTABLE PNEUMATIC TOOLS

The above is the title of a paper read recently before the Institution of Mechanical Engineers by Mr. Bing. Attention was called to the numerous improvements in these tools and to the new tools which have appeared, especially in Great Britain, since the century began. The principal typical uses to which the various tools are put, and especially the effect of their use on the cost of production, was also gone into, showing substantial progress in the last six and a half years in both the tools and the range of their work. Pneumatic tools are now found in use in practically all engineering works, shipyards and mines, not only in America and Great Britain, but all over the world, and in addition, they are largely used by contractors everywhere on constructional work of steel, stone and wood. Not only have the various trades concerned availed themselves largely of the advantages offered by these tools, but at the present time there are many engineering firms in this country engaged in their manufacture; also, the tools produced by them compare very favorably, with regard to accuracy of workmanship and quality of the material employed, with those made on the other side of the Atlantic. Users doubtless might be found who would say that there is still considerable room for improvement, and that the length of life of all kinds of pneumatic tools is not what it should be.

Generally speaking, ordinary work is now done by these tools at a price for labor equivalent to a reduction of from 35 to 60 per cent. off hand labor rates, but on work at all awkward to get at with hand tools the reduction would be greater still. With regard to scaling boilers by pneumatic hammers, Messrs. John Allen & Sons, of Kilburn, give the following comparative figures, one boiler—Cornish, 30 ft. by 6 ft.—only being referred to, the average thickness of scale being ⅜ in. The two pneumatic hammers weighed 9¾ lbs. each, with pistons 1 1-16 in. diameter, and 1¾ in. stroke. When the work was done by hand eight men at 18 cents per hour were employed for nine hours per day, each man receiving 60 cents per day extra as "dirt" money. The job took six days.

Cost per day: Eight men at $2.30.. $13.40
Cost for the six days..............110.40

With two pneumatic hammers, four men employed, two using the pneumatic hammers and two their hand tools, the same job took but three days.

Cost per day: Four men at $2.30..$ 9.20
Cost for the three days............ 27.60
The saving of labor thus being.... 82.80

The riveting hammers are now capable of closing rivets up to 1½ in. diameter, and are employed in all kinds of constructional iron work, both in the yards and in the field; on boiler work, on furnaces, combustion chamber, and shell plating, and in shipbuilding for both shell, bulkhead and deck riveting.

Of all ship work deck riveting is perhaps the easiest to do, because the deck below usually forms a convenient means for supporting the pneumatic holder-on, and where an open hatchway occurs, a plank can readily be laid across. The riveting hammer, too, being used in a vertical position and downwards, is easily held and directed. With practice many riveters become so expert that they prefer to dispense with the carriages provided to support the hammers, and, given a good run of work, reamered holes, plates well bolted up, a good rivet forge, and a smart boy, will make good money at a rate only one-half of that given for similar work done by hand. Much bulkhead riveting is done with the aid of the spring dolly-bar for holding up, especially under conditions in which it is difficult to arrange to support the ordinary pneumatic holder-on.

The amount of boiler riveting done by pneumatic hammers is gradually increasing, and pneumatic tools are to-day employed on all types of boilers, the rivets so driven in many marine boiler shops satisfactorily passing the tests imposed by the Board of Trade and Lloyd's surveyors.

The improvement in pneumatic riveting by the use of the double piston holder-on was so marked that a hammer type holder-on is being introduced, the piston of which is really a valveless pneumatic hammer. Its piston is actuated by the air which is admitted to the back end of the containing cylinder to drive it forward. In use, both hammers strike the rivet together, but, after the head of the rivet has been well set up, the holder-on hammer is stopped by closing the exhaust passages and the point of the rivet finished off, while the head is supported by the holder-on acting in the usual way. By the use of a pneumatic hammer in combination with a holder-on, the operation of which is under control, it will be seen that, under all ordinary conditions of working, the rivet hole at the head can be quite as well filled as at the point, provided the rivet is well heated its whole length, and that it is also insured that the head itself shall be tight up against the plate.

Pneumatic drills continue to form a most important item in the machine equipment of nearly all engineering and shipbuilding works, and since 1900 the number of these machines in use in Great Britain has increased tenfold, a fact strikingly significant of their general utility. On work to which these machines were first applied, such as drilling out stays in repairing boiler fire-boxes of all kinds, driving combustion chamber and fire-box stay-taps, stay-tube taps, turning in stays after tapping the holes, all kinds of drilling and reaming in shipbuilding work, drilling on constructional iron work, etc., they have more than held their own, and the portable electric drill has not yet ousted them from the premier place. The rates paid for pneumatic drilling now vary from 40 per cent. to 75 per cent. off rates paid for hand drilling, depending on the nature of the work. In many shipyards, including the government dockyards, all rivet holes are now reamered out by pneumatic drills. To obtain the best results with wood augers operated by pneumatic drills running at a speed of from 400 to 650 revolutions per minute, the screwed points of the augers should have a pitch of not coarser than twenty threads to the inch. The pitch of the screw, on the point of the ordinary hand auger, is from 8 to 12 to the inch generally, and is much too coarse. Attention to this detail is of the greatest importance. Most of the difficulties attending the use of these portable drills for mining work—drilling or boring in coal or ores—have now been overcome, and various sizes and makes of drills, fitted specially for the work, are now in regular employment, and the number is steadily increasing.

In the design of pneumatic sand-sifters a rectangular-shaped sieve is used, which is mounted on four rollers attached to the top horizontal bars of the frame. It is shaken or vibrated by a valve type of pneumatic hammer of simple construction mounted on the back bracket of the frame, the sieve being attached to the hammer piston by a suitable connection. The sieve is slightly inclined downwards from the hammer, and the lower end is open and comes over the shoot. When working, the coarser parts of the feed are worked along down the incline and out of the sieve at the shoot, while the finer sand falls through between the four legs. Under ordinary conditions of working these machines require two men to shovel sand into the sieve if they are to be kept fully employed. The sieve measures 36 in. by 18 in., but is open for a length of 18 in. only, and the mesh varies from ¼ in. to ½ in. The coarser material passes over the whole length of the sieve on its way to the shoot, and its thorough screening is thus insured, while having the sieve open for only half its length prevents it being overloaded when working. Pneumatic sand-sifters are also arranged for fixing to a post or wall.

Pneumatic sand-rammers are now beginning to play an important part in general foundry and concrete work, such as ramming moulds and cores, tamping concrete clay, road foundations, trenches, etc. Rammers ranging from 7 lbs. in weight with pistons ⅞ in. in diameter and 4 in. stroke to those weighing 280 lbs. with a piston 3 in. in diameter and a 10 in. stroke, striking a maximum blow of over 350 lbs., are now made and are in general use, but more so, perhaps, in the United States than elsewhere. The hammer barrel is longer than that of the ordinary pneumatic hammer, giving a long piston stroke, and the piston is hollow and projects through the front end of the cylinder, the ramming heads being attached to it. The lever for controlling the admission of air is placed so that the operator's hand covers it when the tool is held in the working position. The weight of the blow is regulated by the distance the rammer head is held from the work, the heaviest blow being struck when the piston is allowed to travel its full stroke, and lighter but more rapid blows when the rammer is held closer, consequent on the shorter strokes then made. The front end of the piston to which the rammer heads are attached is hexagon in shape, so that the head can not turn except at the will of the operator. Rammers up to 45 lbs. in weight are handled by one man, but those above this weight are generally suspended to a swinging arm in such a way that they can be readily moved about over the work and raised and lowered as required. Concrete, when rammed in moulds by these tools, sets into sound hard blocks, as the frequent tamping works the air out and packs the sand and cement together very closely. The small hand-rammers enable a man to get through a given amount of work in from one-half to one-quarter the time it would take were he using hand-rammers, and the largest rammer will do as much work as eight to twelve men with hand-rammers.

Compressed air is now used to remove foul air or gas from ships' water and ballast tanks before scaling and painting. It is also used when patented pitch compound is being applied, to carry off the unbreathable noxious yellow smoke given off by the compound, which is put on over a coating of coal tar at a temperature as near boiling point as possible. This work is done in dry dock, and the practice is to knock out a shell rivet as far away from the manhole in the tank top as possible, and attach a hose-pipe to convey the air. When turned on the air effectually drives out the foul gases, and makes it possible for men to remain in the tanks when the hot pitch compound is being applied. In painting the inside plating of ships, the plates, when the ship is afloat, are often wet to a good distance above the water line by condensation of moisture from the atmosphere on the cold surface. Paint will not adhere to plating in this state, but the surface may be easily dried by blowing compressed air over it for a short time, and quickly made ready for painting.

THE USE OF SAND BLAST BY ELECTRIC RAILWAYS

By J. M. Betton.

Although the sand blast has been used in electric railway work for a number of years, its adoption has not been so general as would seem to be warranted by its efficiency and convenience. With only ordinary care and attention it will do good work, and it is especially adapted to electric railways because power for operating an air compressor is always available at any point. An air compressor, either direct connected to the motor or driven by a belt, is easily procured, as is also a steel tank to be used as an air receiver. Consequently there only remains to be selected a sand blast equipment with the proper nozzles, hose, couplings, etc.

Some companies prefer to make their own sand blast apparatus or to use anything that will throw a jet of sand, and perhaps in many cases, as power is so easily obtained, this may appear justifiable. However, it is well to recognize the fact that the machine that will last the longest, stand the knocks and rough handling that come to it, and that is the most economical in its use of air and sand in actual use is the best in the long run. On a street railway, as in any other sort of plant, the saving of small quantities of power and the stoppage of leaks are always worth while, and it is not workmanlike or good business to use a makeshift that wastes power, which always costs the company money. Good sand blasts are obtainable at prices which are more than reasonable when one considers the time and experimenting required to get up a home-made affair.

Sand blast outfits should be of such design that the air supply can be regulated, and if this is applied at several points instead of in bulk at one point, better economy will be obtained. One great advantage is that the air compressor, air receiver and sand blast can be mounted on a truck which will follow the work, obtaining its power from any feed wire.

One of the most important uses of such sand blast outfits is in their use for cleaning the ends of rails previous to bonding. For this work, with a ⅜-in. nozzle and 35 lbs. of air pressure, 100 cu. ft. of free air per minute are required.

It will be noticed that the steel poles used to support the feed or trolley wires often become corroded for a foot or two upward from the base. If no remedy is applied the corrosion will in time undermine the strength of the posts and renewal will be necessary. All of the rust, dirt, scale and accumulation may be removed by the sand blast, leaving a new surface of the clean gray iron or steel, which may be protected by a covering of concrete or cement, thus materially prolonging the life of the pole. This work requires about 35 lbs. of air pressure and can be done quickly with a ½-in. nozzle, using clean, dry and moderately fine sand and 179 cu. ft. of free air per minute.

Similarly all steel structural work, such as bridges, viaducts and elevated railway supports, can be perfectly and quickly cleaned by the sand blast, using preferably a ½-in. nozzle and 35 lbs. of air, increasing the pressure to about 50 lbs. if the sand has to be carried to more than ordinary height. Corners, angles, recesses and other portions of the structure that cannot be reached in cleaning by hand can be cleaned as readily as the plane surfaces of the members.

In all such work the painter's gang should follow closely after the sand blasters, as oxidation is rapid and the object of cleaning by the sand blast is to expose the raw metal, which, being freed from rust, will hold the paint that otherwise would scale off. In like manner steel shapes in stock can be cleaned when wanted for use.

Another use of the sand blast is in the cleaning of the exteriors and interiors of burnt-out controller boxes on electric cars. These are usually cleaned by hand, but the sand blast will do the work four or five times quicker and with greater thoroughness. A pressure of about 25 lbs. and a ⅜-in. nozzle, requiring 77 cu. ft. of free air per minute, can be used to advantage.

The grids from storage batteries that have run down can also be cleaned with the sand blast previous to refilling, using a ⅜-in. or ¼-in. nozzle and about 20 lbs. air pressure, requiring from 31 to 69 cu. ft. of free air per minute. This work should be done out of doors, and the grids should be wet, as the particles of lead and dust are injurious if inhaled.

The bodies of steel cars can be freed from old paint, rust, scale and dirt in the quickest manner by the sand blast, using a ½-in. nozzle under 35 lbs. of air pressure, requiring 179 cu. ft. of free air per minute, and the running gear can be also thoroughly cleaned with the same pressure.

These are only some of the uses of the sand blast in electric railway work, and besides cleaning ornamental work, brasses, etc., its use can be greatly extended in the repair shop and along the line. Considering the ease of operation, the thoroughness of the work done and the very apparent economy over hand work, the use of the sand blast is bound to increase when it has the consideration it deserves at the hands of progressive street railway men.—*Electric Railway Review.*

DISEASES OF CAISSON WORKERS

An International Congress, the fourteenth, for Hygiene and Demography, met in Berlin during the last week of September of the present year. Papers were presented upon a wide variety of topics—usually several upon each—all within the scope of the Congress. Some of the subjects treated were as follows: Smoke Nuisance in Large Towns, Hygiene of Public Thoroughfares, The Railway Service, Sewerage and Sewage Purification, Water and Water Purification, Modern Methods of Combating Typhoid Fever, The Campaign Against Yellow Fever, The Malaria Campaign. *Engineering News* has done a valuable service in preparing summaries of the papers presented, these appearing in its issue of October 24. The following relating to The Diseases of Caisson Workers will be of special interest to our readers:

By J. P. Langlois, Professor at the Faculty of Medicine of Paris.

The proposed regulation is itself the conclusion for this report:

(1) Speed of compression uniformly fixed at 4 minutes per atmosphere.

(2) Speed of decompression gradually reduced with the number of atmospheres: 10 minutes per atmosphere below 2 effective atmospheres, 15 minutes between 3 and 2; 20 minutes above 3 atmospheres.

(3) Length of shift varying between 8 and 4 hours, according to the pressure.

(4) Recompression apparatus for work in pressures of above 2 atmospheres.

(5) Room for rest on the working premises and lodging of the workmen in the immediate neighborhood, for work in pressures of above 2.5 atmospheres.

By Dr. Phillip Silberstern.

(1) The caisson workers occupied in highly compressed air are showing a high rate of morbidity, invalidity and mortality.

(2) The typical disease of the caisson and all other workers moving about in compressed air must be defined as aeraemia. It is produced by large quantities of gases of the surrounding atmospheres (chiefly nitrogen) being absorbed in compressed air by the blood and the liquids of the tissues, and being expelled in the shape of small bubbles, when the pressure is rapidly reduced. Besides the aeraemia, but of less importance, are the affections of the tympanic membrane and the

middle ear, caused by a too rapid compression.

(3) Aeraemia can produce sudden, impetuous, often fugitive, sometimes perilous disturbances in many vascular regions. The most noticeable are air embolism in the regions of the pulmonary circulation, paralysis of the dorsal spine due to ischaemia, phenomena of Ménière, pains in the muscles and articulations.

(4) By returning sick caisson workers into compressed air, the heavy injuries of aeraemia can be prevented. This measure must, however, be resorted to immediately, and consequently lodgings for the compressed air workers near the place of work and a recompression chamber equipped with oxygen inhalation apparatus must be provided.

(5) The frequency and gravity of the compressed air diseases peculiar to caisson workers depend in the first place on the height of the pressure and the rapidity of its drop. Aeraemia does not appear if the pressure does not exceed at least twice the amount of the normal atmospheric pressure. Injurious concomitants can considerably increase the danger, as, for instance, tainted air, sudden change of temperature, rapid variations in the air pressure during the work, certain individual factors and long shifts when the pressure is very high.

(6) Sufficiently slow and uniform decompression is the most important measure for the prevention of aeraemia. The minimum period for the drop of pressure ought to be 1½ minutes for every 0.1 atmosphere of pressure.

(7) A permanent service of supervision by physicians independent of the contractors must be established in all cases where work is executed in an air pressure of more than 1.5 atmospheres above normal; the physicians must exclude from the work all persons physically unfit for it and must immediately give notice to the authorities of every case of sickness, so as to enable them to provide in time for the prevention of grave cases of disease, whereby also useful material for the statistics will be collected.

(8) As the compressed air workers are exposed to great but avoidable danger, they must be offered protection by legal measures about similar to those contained in the "caisson bill" of the Netherlands.

By Hermann von Schroetter, Dr. phil. et. med. (Vienna).

Where there is foundation work done under a pressure exceeding 1.5 atmospheres, a recompression chamber (recompression being the specific remedy) of sufficient size must be provided and oxygen (in steel cylinders) must always be kept at disposal to treat sick persons.

In order not to render the existence of the recompression chamber illusory, the workmen ought to be lodged in special barracks erected in close proximity to the building premises.

Great care must also be taken (especially where the soil is impermeable) with regard to the quality of the air in the working chamber, because impurities in the air—carbonic acid (noxious gases, like sulphureted hydrogen, carbonic oxide), high temperature, moisture—favor the appearance of pathologic symptoms during the period of decompression. Consequently, sufficient ventilation by means of cooled compressed air containing but little moisture and supplied at the rate of about 50 cu. m. (1,750 cu. ft.) per head and hour, as well as the use of electric light must be demanded.

In order to prevent physical fatigue, which also favors the appearance of pathologic symptoms, the duration of work in compressed air must be regulated. Up to a pressure of two atmospheres two shifts of 4 hours each are admissible in 24 hours, the time required for compression and decompression being included in these periods. If the pressure amounts to 2 to 3.5 atmospheres the work time, inclusive of time for locking in and locking out, must not be longer than two shifts of 3 hours each per 24 hours. A period of 8 hours at least must be allowed for rest between two shifts. Where work is done in depths of more than 20 m. (65 ft.) lifts ought to be used. The air lock must be easily accessible.

For the above reasons only persons in a perfect state of health (of heart, vessels and lungs) must be employed for work in compressed air; fat, plethoric individuals cannot be admitted.

The air space in the air lock must amount to a minimum of 0.6 cu. m. (210 cu. ft.) per head. During decompression, constant ventilation (simultaneous entrance of fresh compressed air) of the air lock must be provided.

Depth of respiration and acceleration of the blood circulation favor the liberation of the body from gas.

The supply of air must take place at a pressure as constant as possible. Each air supply pipe must be provided with a valve closing automatically when the pressure decreases in the periphery for any reason whatever. Spare pumps must always be kept in readiness.

DEEP MINE SHAFTS AND THE EARTH'S ROTATION

If you go to the Red Jacket shaft in Michigan, says Ralph Pine in a current magazine, whose identity has unfortunately escaped us, you find the most powerful hoisting machinery in the world, huge engines of as much as 8,000 horse-power, which reel and unreel drums of wire cable that wind down a straight mile below the surface. These engines hoist ten-ton cars of ore one mile at the rate of forty miles an hour, or from the bottom to the top of this stupendous hole in the ground in ninety seconds. This is the deepest mining shaft in the world. Apart from this fact, perhaps the most interesting feature of the Red Jacket shaft is in the theory that it is possible to detect the effect of the earth's rotation in a hole as deep as this. No less an authority than President McNair, of the Michigan College of Mines, has explained the belief that nothing dropped in this deepest of mining shafts can ever reach the bottom without colliding with the east side of the shaft.

"This is due to the motion of the earth," said he. "The article dropped, no matter what its shape or size may be, will invariably be found clinging to the east side of the shaft. One day a monkey-wrench was dropped by a miner, but it failed to reach the bottom and was found lodged against the east side of the shaft several hundred feet down. We decided that to make a proper test of the theory it would be worth while to experiment with a small heavy spherical body. So we suspended a marble tied with a thread about twelve feet below the mouth of the shaft. We then burned the thread with a lighted match in order not to disturb the exact fall of the marble. About 500 feet down it brought up against the east side of the shaft. When miners have fallen down the shaft the result has been similar. Their bodies, badly torn, have been found lodged against the east side of the shaft. A carload of rock was dumped down the deepest mining shaft in South Africa, but not a particle of it reached bottom."

TO KEEP COPPER BRIGHT

The Brewers' Journal says that the way to keep copper bright is by the use of Zapon varnish, which is a solution of celluloid having an intense odor resembling that of fruit. The copper surface must be thoroughly cleaned and all old varnish removed by scouring with fine sand and water, the final traces of oxide film being removed with a 10 per cent. solution of saccharic acid, leaving the copper bright and shiny. Every trace of the saccharic acid must then be eliminated by washing with water, and the surface afterwards carefully polished with Vienna lime and a little water. Then the surface is ready for varnishing immediately to avoid renewed oxidation. The Zapon varnish is laid on with a pledget of cotton batting by one workman, while another spreads it out evenly with another cotton batting pad, so as to form a very thin coat on the surface of the metal, thicker layers being liable to turn yellow when heated. Any spots not covered with varnish are exposed to oxidation and will show very soon. Care must be taken that the metal be perfectly dry before applying the varnish, even contact with a moist hand being injurious, and the coated surfaces must be left for some time before use, or the deposition of moisture may cause stains. Except for parts in contact with escaping steam, the varnish only needs renewing about once a year, and in the interval no washing is required, the surface being merely wiped over with a cloth. The hands of the workmen applying the varnish can easily be cleaned with acetone.

THE NEW HUM OF INDUSTRY

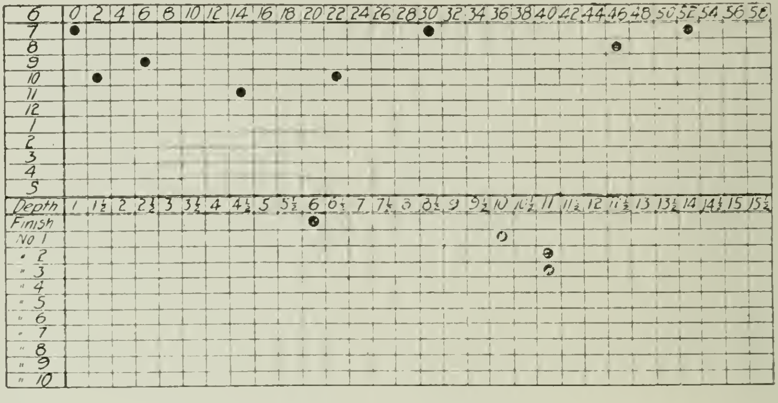
We speak of the hum of industry: one has never really heard it until he has stood in the growing hull of a 600-foot long steel ship and heard a hundred pneumatic riveters at work. Sign language only is used there. Compressed air is the magician. Even the rivet boys are not allowed to lose time pumping bellows at their forges; a tiny stream of compressed air supplies them with forced draught. If a rivet is countersunk, the rough surplus projecting is not slowly smoothed away by man power and hammers and chisels; a pneumatic tool does it in a few seconds. If an emergency requires a rivet hole which has not been punched, a pneumatic drill does the work as deftly as a cook trims a pie crust.—*Gunter's Magazine.*

A ROCK DRILLER'S RECORD CARD

Engineering-Contracting has devised a daily record card for rock drillers, shown on this page, which should be welcome to both the driller and the contractor or other employer. From the nature of the rock driller's work it is inconvenient to use a pencil, and such a record would often become illegible, so with this card only a small conductor's punch is used. A new card is to be given out to the driller every morning and each card is marked on the back with the date and the designating number or letter of the driller.

The upper half of the record on the face of the card has to do entirely with the time of drilling, and the lower half with the depths of the holes as drilled. For the time record the hours are in the vertical column at the left and the even minutes in the horizontal line across the top. The holes drilled are recorded numerically at the left of the lower half of the card, while the depths in halves of a foot are indicated at the top of the lower half. The first hole begun in the day is No. 1, and so on. If a hole was begun the day before and finished in this record a line designated *finish* is provided for this above No. 1.

If we go over the actual record shown on this sample card everything will be clearly understood. We see that the drilling began at 7 o'clock and a hole was finished at 7:30. The depth drilled to finish this hole was 6 feet. Hole No. 1 was begun at 7:52 and finished at 8:46, this No. 1 hole being 10 feet deep. The drilling of No. 2 was begun at 9:06 and finished at 10:02, and it was 11 feet deep. No. 3, begun at 10:22, finished at 11:14, and 11 feet deep. The elapsed time between the finishing of one hole and the beginning of the next was of course occupied in moving and re-setting the drill. By this record the total time was 234 minutes and the total depth 38 feet, which made the rate of drilling 6.16 minutes per foot. The actual drilling time was 192 minutes and the rate 5.05 minutes per foot.



A ROCK DRILLER'S RECORD CARD.

ASSISTING THE SOLUTION OF GOLD IN THE CYANIDE PROCESS BY COMPRESSED AIR

The following suggestion was offered by Mr. Andrew F. Crosse at a recent meeting of the Chemical, Metallurgical and Mining Society of South Africa:

For many years I have been impressed with the idea of using compressed air, produced by a "trompe," for assisting in the solution of gold in the cyanide process. Time forbids my entering into a description of the trompe, but I believe that a trompe was first used in the Pyrenees, during the middle ages, for iron smelting. In this district (Pilgrim's Rest) we have abundance of water power, and I erected a small trompe on my arrival here last October.

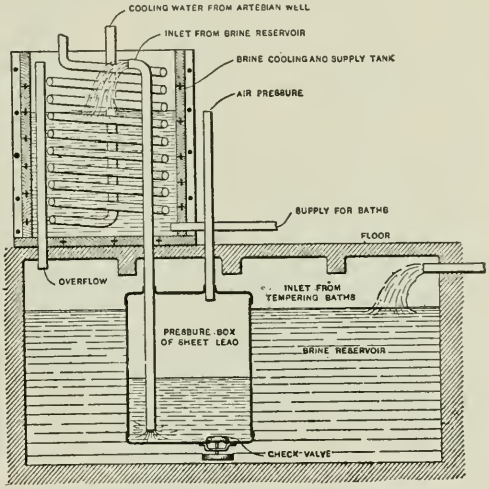
More than half the gold here is contained in the slime, so that a high extraction from the latter is absolutely necessary. You are probably acquainted with the Pohlé pump, which is the exact opposite of the trompe, the latter being an arrangement by which compressed air is formed, by being sucked down by water and delivered under pressure, whilst the Pohlé pump is an arrangement by which water, or any other liquid, can be lifted, under given conditions, owing to the reduction of its specific gravity, by the admixture of air. I make use of a conical vat, with a vertical pipe in the center of the same, through which the pulp in the vat is lifted by compressed air, supplied by the trompe, 2 ft. above the surface of the liquid; it falls over into an outer tube and is discharged through four pipes, having their orifices tangentically arranged so as to force the pulp into a circular motion. By this means I obtain full aeration and very rapid circulation. The solution of the gold is extremely rapid, and there is no machinery of any kind, it being absolutely automatic.

As this method was so very successful, I applied the same principle, slightly modified, to the sand treatment. The sand must be perfectly clean and free from slime, such as is obtained from the Wilfley concentrator. I have arranged a vat from which the solution drains off into an air-lift pump; this solution is circulated through the sand. After a few hours the sand is full of air bubbles, and a rapid circulation of the liquid is maintained. These air bubbles are formed owing to the cyanide solution being surcharged with air, and they are deposited on the sand, in the same way that a piece of bread, thrown into a glass of champagne, is coated with carbonic acid bubbles. I have obtained 92 per cent. extraction of the gold by this means from 6.2 dwt. tailings in 24 hours, including washing. This result is, I believe, a record.

FOR A COOL SUPPLY OF BRINE

In a valuable article in a recent issue of *Machinery,* describing the manufacture of Swiss files in the United States, an interesting account is given of the arrangements for maintaining a constant supply of cool brine, which is so important an agent in the hardening processes of the establishment. The apparatus is shown diagrammatically in the cut.

The underground reservoir contains a saturated solution of salt and water. This tank is of wood, on which, of course, the brine has no injurious effect. Located within it is a box of sheet lead, with an inwardly opening valve of the same material at the bottom, and an air supply pipe and an outlet pipe, also of lead, entering the top. The latter of these two pipes comes nearly to the bottom of the box. The operator at either of the two hardening furnaces, by pulling a cord, can open a three-way valve, which admits air under pressure at the top of the box. The box being full of brine, which has flowed in through the check-valve at the bottom, the air pressure closes this valve and forces the liquid through the outlet pipe into the cooling and supply tank above. This latter tank is high enough so that the brine flows from it by gravity to the bottom of the tanks at the furnaces. The cooled brine entering at the bottom of these tanks rises and displaces the warmer fluid, which runs through an overflow at the top back to the reservoir again. In the cooling tank is a coil of pipe, through which water flows continuously from an artesian well sunk on the premises. This serves to keep the supply of brine cooled.


COOLING WATER FROM ARTESIAN WELL
INLET FROM BRINE RESERVOIR
BRINE COOLING AND SUPPLY TANK
AIR PRESSURE
SUPPLY FOR BATHS
FLOOR
OVERFLOW
INLET FROM TEMPERING BATHS
PRESSURE BOX OF SHEET LEAD
BRINE RESERVOIR
CHECK-VALVE

Cooling Brine for Steel Hardening.

An interesting use of paper is in the making of gas pipes. Manila paper cut in strips, as wide as the length of the pipe to be made, is put into a receiver filled with fused asphalt, and rolled solidly and uniformly around a rod or core of iron until the desired thickness is obtained. After the pipe, thus produced, has been submitted to a heavy pressure, the exterior is covered with sand, and the whole cooled in water. The core is then removed, and the outer surface covered with a waterproof product.

THE COMPRESSED AIR FUNCTION ON THE DIESEL ENGINE

The accompanying cuts give us two sectional views of a 250-h.p. Diesel engine built at Augsburg, Bavaria. The cylinders are 19¾ inches in diameter, the stroke is 29 inches and at 155 revolutions per minute, or 750 feet piston speed, the nominal power is developed. The trunk pistons are 39¼ inches long, giving ample lateral bearing for the angular thrust of the connecting rod. With two fly-wheels 13 feet in diameter and weighing together about 22 tons, the inequality of the turning movement is said not to exceed 1-140. The action is four-cycle, so that the placing of the two cranks together on the same side of the shaft distributes the drive equally.

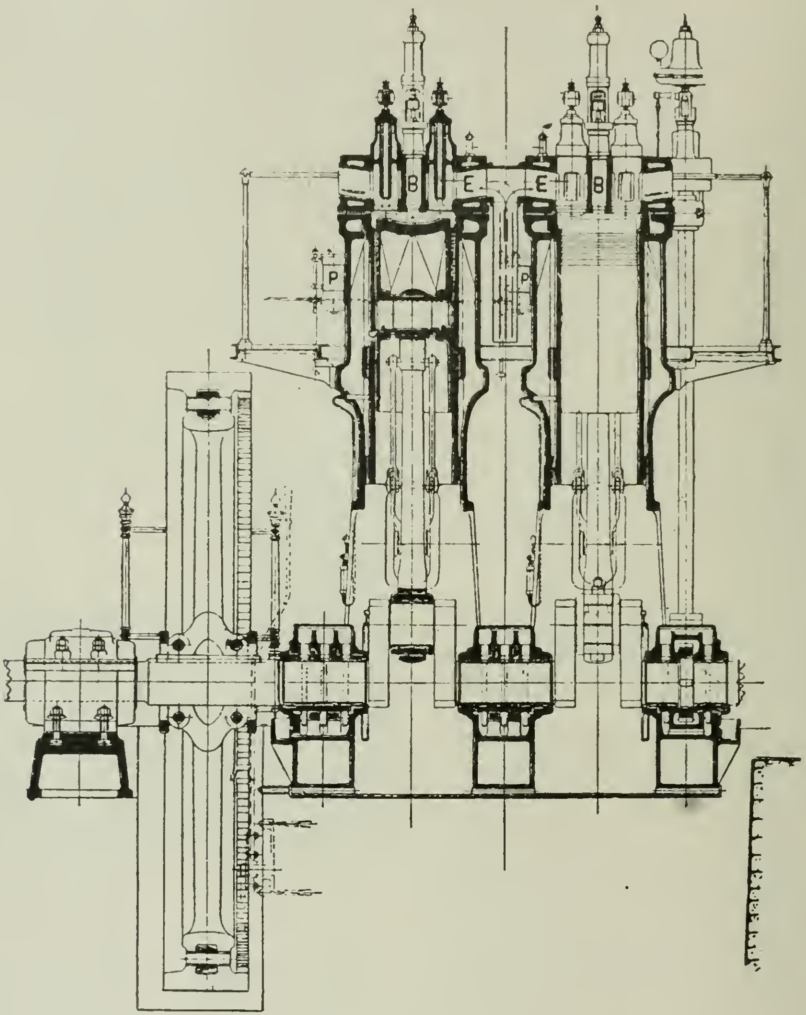


Fig. 1. Vertical Longitudinal Section of Diesel Engine.

Considering either cylinder separately, the following is the cycle of operations:

1. The piston moves downward and the cylinder is filled with normal atmospheric air.
2. The piston moves upward, compressing the air and making it very hot.

3. At the instant the piston begins to go down again the charge of liquid fuel for the stroke is injected, mixing with the heated air and being fired, with the result that the pressure is greatly increased by the explosion. This pressure, gradually falling as expansion takes place, constitutes the driving force which continues throughout this downward stroke. The fuel is injected at the beginning of this stroke by means of compressed air, the pressure of which must naturally be higher than that within the cylinder, being actually from 750 to 1,000 pounds.

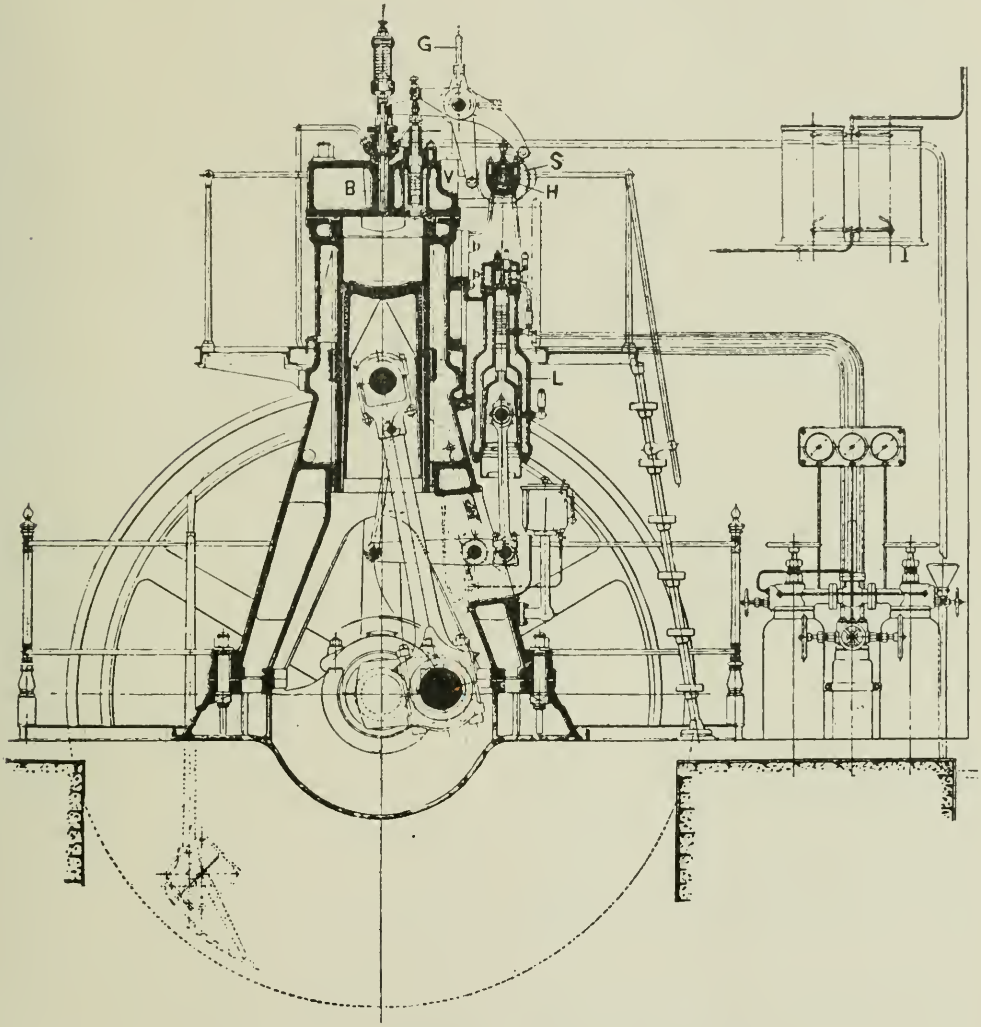


FIG. 2. VERTICAL TRANSVERSE SECTION OF DIESEL ENGINE.

4. The piston goes up again, driving out the burned and expanded mixture, thus completing the cycle.

Each cylinder has four valves; the starting valve V, for admitting the compressed air; the suction valve E, for the atmospheric air; the fuel valve B, for admitting the liquid fuel into the cylinder; and the valve for discharging the exhaust gas. All the valves are closed by springs and are opened by levers which are actuated by cams S. The cams are all placed upon a common horizontal shaft H, which turns at one-half the speed of the crank shaft and is driven from the latter by helical gears and a vertical intermediate shaft. The levers for the starting and the fuel valves, moved by a handle G, are so connected that they cannot both be opened at the same time.

The operation of starting the engine is quite simple. A device is provided for barring the engine over by means of teeth or notches in the fly-wheel, the pistons are thus brought to the upper position and the crank is brought a little past the dead center. Compressed air from the starting reservoir, shown at the lower right hand corner in Fig. 2, the air having a pressure of, say, 50 atmospheres, is admitted to the cylinder by the valve V, and the engine starts, and after two or three revolutions driven by the air pressure it gets up to normal speed. The handle G is at once put over to the running position, closing the starting valve V, and opening the fuel valve B. Compressed air from the air injecting reservoir, which is separate from the starting reservoir, drives the liquid fuel into the cylinder and the regular working of the engine is established, the air injecting operation continuing while the engine is running.

Compressed air for the starting and the injecting reservoirs is provided by two-stage, single-acting compressors attached directly to the engine. Each engine has two of these compressors driven by links attached to the connecting rods. A pressure of 60 atmospheres is maintained constantly in the starting reservoir, and as soon as this pressure is reached it is shut off from the compressor. The air injection reservoir is in constant service when the engine is running, and its pressure is maintained by a continual supply from the compressor. The liquid fuel is delivered to the injection system by a special pump P driven from the cam-shaft H. The valves of this pump are acted upon by the governor, which thereby controls the supply of fuel per stroke and the power developed in consequence, the regulation by this means being as close as may be desired.

The compressor here is a part of the engine just as condenser and air pump were formerly integral parts of each condensing steam engine then built. As later steam engine practice has developed the separate and independent condenser and air pump, so the later and larger Diesel engines, especially of American build, are employing independent air compressors. The machine used is a belt-driven, three-stage compressor, which we may illustrate in a future issue.

COMPRESSED AIR AND HEALTH OF DIVERS AND CAISSON WORKERS

A lecture by Mr. Leonard Hill, F. R. S., given at the recent engineering exhibition held at the exhibition building called Olympia, London, dealt exhaustively with the physiological effects of compressed air on the human body. The following is an abstract of a report in The Engineer, London:

In connection with many important engineering works where men have to carry out operations under compressed air, careful precautions are taken to minimize, as far as possible, injury to the health of the workers, and resident medical officers are employed. Caisson disease is far more frequent in its occurrence, and undoubtedly a great deal of it is due to the carelessness of workers and disregard of rules and regulations. In the case of helmet divers working at considerable depths, it is unusual to find them taking the precaution to decompress slowly, and most of the disease and ill-health of professional divers is due to the too rapid decompression commonly practiced.

The theory of congestion of the blood in the deeper parts of the body induced by variations of atmospheric pressure, is contrary to physical principles, and is quite untenable. Whether it be air or water that uniformly presses upon the body, the tissue fluids transmit the pressure equally, and no mechanical effect is produced. In the modern diving dress the compressed air keeps the water from entering at the cuff. If the dress tears water enters and the body becomes wet, but the man is in no danger, for the air keeps the water out of the helmet. Quite recently the dress of a diver split at a depth of over 130 feet, and it became filled to the level of the helmet. Even at this depth, with a pressure of more than 60 pounds per square inch on the body, no ill results were experienced.

With the exception of a slight ear trouble, none of the symptoms of compressed air sickness occur while the men are under pressure. The ear trouble is due to the inequality of pressure on the two sides of the ear drum. The cause of compressed air sickness is that the nitrogen is dissolved by the blood and the body fluids and, and when the body is decompressed the gas bubbles off in the blood. These bubbles may block up the capillaries locally, producing, according to location, deafness, vertigo, spinal paralysis, etc. The illness is prevented by making the rate of decompression sufficiently slow, that is, by allowing time for the dissolved nitrogen to escape from the lungs. Lard will dissolve four times as much nitrogen as water, which seems to suggest a point in favor of the employment of lean men as divers.

The lecturer, Mr. Hill, and Mr. M. Greenwood have had a number of interesting personal experiences under high pressures. In a special steel tank Mr. Greenwood was subjected to a pressure of 92 pounds, equivalent to a water pressure of 210 feet. The time of compression was 54 minutes, and of decompression, 137 minutes, the subject experiencing no inconvenience beyond a little temporary pain in the arms.

The precautions to be observed are, first, that at least twenty minutes shall be allowed for decompression for each atmosphere of pressure, a uniform rate of pressure reduction being maintained; and, secondly, that the capillary circulation in every part of the body be maintained by muscular action during the decompression. A record dive was once made of 204 feet (88½ pounds), but the diver died on reaching the surface. Probably the greatest depth an English diver has gone and survived is 189 feet.

The young man who is in perfect health, with powerful heart and deep respiration, can expel the dissolved nitrogen from his lungs far more rapidly than the old, the intemperate, or one who is over-fatigued by excessive labor; and the fat man probably takes up a far larger volume of nitrogen than the thin man. The records of caisson works seem to show that men under twenty to twenty-five years of age escape; that long shifts increase the number of cases; that men who work the air locks, passing material through, and undergoing frequent and short-lasting compression and decompression, are not affected. The longer the shift the more complete the saturation of the body; the higher the pressure the greater the risks and the graver the symptoms. The records show that practically no cases occur with a pressure below 1½ atmospheres, even though the decompression period be made only a minute or two.

Records seem to show that bad ventilation of pressure spaces increases the cases of illness. The medical officer at the Blackwell Tunnel Works held that it is necessary to keep the carbon-dioxide in the air under 0.1 per cent., and this is actually being done now at the Rotherhithe tunnel works at great expense, by the supply of an exceptionally large volume of air to the tunnel face.

We must apparently look to other accompaniments of bad ventilation to discover the sources of the ill effects which result from that condition. Mr. Hill suggests the presence of carbon-monoxide (CO) as a likely cause, and adduces reasons for his opinion. CO is produced in considerable quantities in caisson and tunnel works where flare lights, furnaces and blasting charges are used, or where low-flash oils are employed to lubricate the compressors. It is a fact that the men who worked in the diving bells at the Dover harbor works were free from illness in contrast with caisson workers at the same pressure. The sickness among workers in the New York subaqueous tunnels is considerable, and in the Hudson tunnel works eight men died in six months last year. Mr. Hill suggests that the freedom of the air from CO is possibly one of the causes of the Dover immunity. In connection with the New York tunnel works now in progress "medical locks," or recompression chambers, are used with very satisfactory results, and many serious cases of illness have been beneficially treated by recompression and subsequent slow decompression.

THE ANTHRACITE CENTENNIAL

On the night of February 11, 1808, Judge Jesse Fell, of Wilkesbarre, first demonstrated to his friends and neighbors that anthracite would burn. Pennsylvanians are preparing to fittingly celebrate the centennial of this epochal event. The estimated output of anthracite in Pennsylvania for the year 1907 is 66,500,000 tons, exceeding all previous records. It is peculiarly gratifying to note that two important discoveries of this unique fuel have been made recently. A vein of as yet undetermined but considerable extent has been discovered only a mile north of Gettysburg. It lies only a foot or two below the surface and is said to be eight or nine feet thick. The other discovery spoken of is in the Lehigh field, where a seven-foot vein of the richest fuel has been struck.

ROCK-DRILL ECONOMICS

A paper was read recently before the Chemical, Metallurgical and Mining Society of South Africa by Mr. G. M. Weston, in which he presented various suggestions on the promotion of rock-drill efficiencies. On the question of air pressures he was most emphatic, and he remarked that, under present conditions [speaking, of course, of South African practice.—Ed. C. A.], nothing like reasonable efficiency can be expected from the rock drills. He entered a plea as follows for more data regarding the results obtained by rock drills:

"We have thousands of horse-power applied to boring rock, and yet we are working very much in the dark regarding the true economy of the process. For instance, we know it cannot pay to use a drill-bit after it has been blunted to a certain degree; yet thousands are used twice, and we really know nothing of the amount of loss in boring, say, a foot with blunt steel against a foot with sharp steel. In mechanical engineering the exact angle of the cutting bit is calculated for different work in different material. Conditions are, of course, different in rock boring; but no experiments are made to find the best angle for cutting edges of drill-bits, and what difference a cutting edge of 90 degrees makes to one of 60 degrees in hard and soft rock respectively. Taking into consideration the extra cost of sharpening, providing and removing extra steel, time lost in changing bits, would it not pay to run steels in big machines with a difference of 12 or 15 inches instead of 18 or 24 inches? In boring average reef, what is the best ratio to start with of foot pounds of average per inch length of cutting edge for the blow given by a rock-drill? What is the best relation between mass and velocity for the striking body? For instance, would not a 2½-inch machine drilling at 80 pounds pressure bore faster, even with the same sized bit, than a 3¼-inch machine working at 60 pounds? All these and a host of other questions are, I think, worth answering. Some few experts and some manufacturers may know all about them; but I doubt if they do.

"How much more must a machine that costs $20 per month for maintenance bore than one that costs only $10 per month? Obviously supposing that rock broken costs $1.50 per ton and that a 4-foot hole will break one ton, it has only to break seventeen extra per month, or 6 inches per shift, to pay for itself."

A PECULIAR MINE EXPLOSION

On Thursday, September 12, there occurred at Mine No. 10 of the Union Pacific Coal Co., Rock Springs, Wyo., an explosion of dust, which in its cause and effects is unique in the annals of coal-mining accidents. The accident occurred at about 5 o'clock in the afternoon, when the miners were preparing to leave the mine. About forty of the miners had gathered at the foot of the slope when a trip of empties was started from the top. The coupling between two of the cars had not been properly made, and when the trip reached the head of the slope six of the cars started down the 20 per cent. incline unchecked. By the time they had reached the bottom they had acquired a terrific speed, and collided with a trip of full cars waiting there to be hoisted. Fortunately the men had gotten out of the way of the runaway cars and no one was killed by them, but the impact created a cloud of dust, raised principally from the floor of the gangway, and this dust was ignited by the lamps of the miners. It appears that the mixture of dust and air was not of a character to produce a violent explosion. The results seem to indicate that the quantity of air was below that required to make a highly explosive mixture, and to this must be attributed the escape from death of the forty men injured. There was, however, an instantaneous combustion which produced sufficient heat to burn more or less seriously every man in the immediate vicinity, but none of them so badly that he was not able to walk or crawl out of the manway. The force of the explosion was felt more seriously 200 or 300 feet down the gangway, where a miner standing at the entrance to the mine stable was thrown violently down and sustained a broken arm and other injuries. He was the only man who had to be taken from the mine. One of the peculiar and fortunate effects of the explosion was the partial wrecking of an overcast a short distance east of the slope. This resulted in a short-circuiting of the air current, and as the slope and manway were intakes, large quantities of fresh air, drawn by a powerful fan (which was uninjured) were supplied to the men and carried off the products of combustion, preventing any deaths from suffocation. The air current was so strong that the writer could find no ash or other evidence of the combustion which had taken place.—*Mines and Minerals.*

LARGE INSTALLATIONS OF ELECTRICALLY DRIVEN AIR COMPRESSORS

The following we take from an interesting article by Andrew Floyd Bushnell in *The Engineering and Mining Journal,* November 2:

An authoritative statement from the Amalgamated Copper Company shows that where it costs $100 yearly to produce 1 h. p. by steam, electrical power will cost only $50. [This electric power coming, of course, from water power.—Ed. C. A.] The numerous mines controlled by the Amalgamated Company use approximately 7,000 horse-power in compressing air. Not all these mines have discontinued the use of steam, but they will in time, and when that is done, the Amalgamated Company will save approximately $350,000 per annum.

There are two Ingersoll-Sergeant compressors at the Original mine, which also furnish air for the Gagnon and West Stewart mines. Two 500-h.p. General Electric induction motors, 2,000 volts, are installed. The fly-wheels make 87 revolutions per minute, and the air pressure varies from 80 to 90 pounds per square inch.

The largest air-compressor plant in Butte is at the Neversweat mine. This comprises five large machines. There are two electrically driven Ingersoll-Sergeant compressors. One, 50¼x30¼x60 inches, and 44 revolutions per minute, is driven by three 300-h.p. motors and has been running two and a half years. The other electric compressor is 30¼x60 inches, single stage, and is driven by an 800-h.p. motor; it makes 47 revolutions per minute. This machine has been running five years. The three steam-driven compressors at the Neversweat are duplex, single stage, 30¼x60-inch. The Rarus has two electrical compressors, 39x24x48-inch. One compressor at the Corra is of the same capacity as those at the Rarus; the other is 23¼x40¼x48-inch. They were all made by the Ingersoll-Sergeant Company.

The most up-to-date plant at Butte is at the Bell mine, where four large Ingersoll-Sergeant compressors are installed. These machines are 38¼x24¼x48-inch and the fly-wheels make 60 revolutions per minute. Except where otherwise stated the compressors of the Amalgamated Copper Company are driven by 600-h. p. General Electric or Westinghouse motors.

The Bell compressor plant, complete, cost $250,000. The building is 100x130 feet, and the foundation consists of 20-foot concrete walls. The compressors are supported by massive cement pillars. The compressor plants of all the large Butte mines are so arranged that should one meet with an accident, the mine affected can be supplied with air from another plant. The steam plants are always kept in running order in case any accident should befall the power plant.

LONDON'S ATMOSPHERIC ECLIPSE

Wednesday, November 20, was a day that will be remembered in London as one of the most detestable this city ever has known. Practically the whole of the day it was dark, dismal night. There was no dawn at the hour when morning light usually drives away the night's gloomy shades; the darkness actually grew denser as the morning came. It was not fog that blackened the sky, although there was some of that about; as one looked overhead it seemed as though all the smoke that had poured out of London chimneys for a month had settled down over the city in a thick black pall. It was a solider, much more substantial darkness than the sort one cuts up into chunks with his carving knife; it was of a sort to be blown to pieces with dynamite.

Another peculiarity of the darkness was that it stayed aloft, and so did not cause so much inconvenience as a thick fog is apt to cause. One could see a fair distance along the street, just as one can see in the night-time. In fact, the streets looked about as they look at night, when the lights are aflame in the shop windows, the offices, and residences. Above it was inky dark; on the street level it was merely the normal night. At the hour when the sun, according to the solar experts at Kensington, was at the meridian, the shop-keepers of Piccadilly, the Strand, Regent street, and all the other business thoroughfares had every light in their establishments burning at full head. The upper floor of the British Museum had to be closed because the darkness made the exhibits on that floor quite invisible. At various points one could read with difficulty electric light signs that were fixed at heights not above fifty feet. Other signs higher up worked in vain, conveying no messages to the people. Such of the illuminated clocks as were fairly close to the ground could be consulted profitably; the rest looked the debilitated anaemic little moons, and told the hours to no useful purpose.

There were some weird effects to be seen as one watched the black vapor from his roof or from a lofty window. I saw a great volume of smoke pouring out of a bakery chimney rise in an almost straight line for ten feet or so. But when it came in contact with the overhanging pall, it flattened out into a great black disk, which presently was absorbed into the pall and became a part of its Nubian darkness. It was well along in the afternoon before the vapor began to clear away, the atmosphere first turning from black to sickly green, and then gradually lightening until at length blue sky came into view, with here and there a twinkling star. Our real night was gladly welcomed after the literally awful blackness of our miscalled day.—From wireless dispatch to *New York Times.*

LIQUID AIR IN DERMATOLOGY

In the *Journal of the American Medical Association* of August 3rd Dr. Henry H. Whitehouse gives his personal experiences in the use of liquid air in dermatology. A mild and short exposure of the normal skin to a spray of liquid air produces blanching, followed by a moderate congestion; a longer exposure freezes and anæsthetises the part. In applications by means of a swab of cotton wool the resulting inflammatory swelling varies in degree according to the amount of liquid air used, the pressure applied, and the location and character of the tissues. The pain produced is very slight and rarely lasts long. In pathological conditions liquid air relieves pain after a few applications and lessens discharge and odor; it diminishes tendency to hemorrhage and encourages healthy granulation. It produces very little reactionary effect on scar tissue, hence it is of distinct diagnostic value in epithelioma. Dr. Whitehouse points out that extravagant claims were at first made for liquid air in the treatment of many disorders which may be more conveniently treated by simpler methods, including abscess, bubo, boils, carbuncles, ulcers, and warts. It is unnecessary, also, to resort to liquid air for the production of local anæsthesia. There are, however, many disorders in which better results may be obtained with liquid air than with other remedies, particularly in pigmentary, hairy, and vascular nævi, angiomata, lymphangioma circumscriptum, lupus erythematosus, lupus vulgaris, and epitheliomata. Dr. Whitehouse suggests that the secret of success with liquid air lies in the technique. The cotton swab is applicable to all conditions and with a little experience can be used with great precision. Pine sticks of sufficient length to reach the bottom of a Dewar bulb, and so shaped that the liquid may be applied in any quantity, are bound at the end with absorbent cotton to form a flat, round-pointed, or paddle-shaped pad. The excess of liquid should be shaken off and scabs should be completely removed from all lesions to be treated, a thin layer of gauze intervening between the applicator and all mucous or denuded surfaces, otherwise the scab will freeze fast. The factors governing the effect produced are the degree of saturation of the swab, the accuracy of contact, the amount of pressure exerted, and the duration of the exposure. The success of the treatment depends upon a thorough appreciation of these factors coupled with correct judgment respecting the interval allowed between exposures.

CHEAP WATER POWER IN SWITZERLAND

The following data are given of the cost of developing a water power at Vallorbe, in Switzerland. The height of the fall is 70 meters (229 feet), and 3,000 horse-power is used. The expenditures were divided as follows:

Concession and land........	$6,000
Dam	4,000
Tunnel, etc.	10,000
Pipe line	6,000
Turbines and sluice-gates....	22,000
Buildings	4,000
Dynamos	60,000
Sundries	8,000
	$120,000

Thus the cost per horse-power was $40. Interest and depreciation at 10 per cent. make $4 per horse-power per annum. These results are exceptionally favorable, even for Switzerland; more usually the cost of installation would average $80 per horse-power, and the annual charges $8.

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A NEW VOLUME OF HOPES

Compressed Air, as is most convenient and proper, now and hereafter, is to begin and end its volume with the year. We are hopeful and confident of making the volume now beginning the most notable in the history of this publication. This does not mean that it is to be either the largest or the best, because succeeding volumes should easily surpass it if life and growth continue and only the latest should be really the best. We wish, however, to make a new departure and to get on a more accelerated gait. Heretofore the opportunities of the publication have not been realized and its possible scope is still far from full development. Compressed Air, the publication, having to do with compressed air, the physical fact, of course has to do also with the compressing and manipulation of it, beginning with it in its most attenuated condition and reaching up—or down, is it?—to its liquid and solid states. Air, rather than compressed air, so called, is what we really deal with, so that we not unnaturally may claim as our constituents and supporters all who have interests in the air itself or in any of the various applications and employments of it. Having to do with the physical transformations of it, as to pressure, temperature and volume, and with all the agencies of these transformations we also are interested in its properties, conditions and uses in either state. The touch of air compressed leads us down into the deepest mines to see it ripping out Earth's treasures, and air uncompressed, free air, the freest air, is also ours for aeronautics; and now that, as it would seem, we are really making some actual successes in the art of flight, who shall have the telling of it if we may not? Also it is in our way to know the air still more intimately, to know about the gases of which it is normally composed and of those which may abnormally adulterate or vitiate it. Practically every article or item in our present issue is true to our general topic, each touching the air in some of its relations and in each of which some of us should be interested. We aim thus to promote the interests and to stimulate the interest of all. In our work we will be glad to have the help and coöperation of all, and there are few whom we can help who cannot also help us. One of the most valuable features of such a publication as ours might be and should be in published correspondence and discussion. Kindly send us your letters of information, of inquiry, of correction or suggestion, of encouragement or reproof. All of our material must really come to us from outside sources, and the more of it comes from friends, or from those most interested or best informed, the better for all of us.

THEORETICAL AND PRACTICAL MACHINE TESTS

The essential point of difference in the traditional and perpetual contest between the theoretical and the practical, in which the latter is so generally the winner, is apt to be not that the former is wrong in any particular but only that its grasp is not all comprehensive. It does not take into account every detail of function which might help to affect or determine the ultimate result. This is frequently shown in the tests of engines and machines which are made by college professors and those associated, and the reports of which have been apparently the favorite filling for the transactions of the societies, in which are determined the consumption of coal, of water, and sometimes even of oil, with usually nothing beyond that.

These reports of fuel economies are innocent enough in themselves, but when they become the sole evidence relied upon in the selection of apparatus for any purpose they are misleading and cannot alone secure the most efficient and satisfactory service. It happens that in addition to the consumption of fuel *the consumption of engineer* is often an important and many times should be the determining consideration. One line of machines may require much more of skill, of care and watchfulness, of minute precision of adjustment than another, and these things are costly. The consumption of time also when delays occur from wear, breakage or derangement, and to which also one machine may be vastly more liable than another, may out-weigh all the possible savings of coal ten times or a hundred times over. The cost of damaging or destructive accidents, the possibilities of which may inhere in one machine more than in another, may in a minute or an hour wipe out a year's saving at the coal pile. The practical testing of a machine, the testing by continuous, every-day, money earning work, cannot fail to take full account and impartial account of every particular which may assist in determining the ultimate economy of operation, and the practical test, therefore, is the only one finally accepted.

There is a certain air compressor, a pioneer in the larger, more serious and responsible business of air compression, which has held its own phenomenally and is still very much in evidence. It has been built in greater numbers, has held more responsible positions, has done more work, has proved itself more reliable in every-day, all-the-year-round service, as well as for all sorts of emergent, exacting and unusual conditions, than any other in the world. It has been overcrowded, abused, neglected and its good name has been attacked both openly and covertly, but it has kept on its way with wonderful pertinacity. Its vitality, to those who are not familiar with the various episodes of its career, is perhaps its most wonderful characteristic.

And yet the explanation is simple. The machine is fairly efficient in every detail of its working, but above all it is reliable. This reliability is the largest factor and the one given first consideration when ultimate efficiencies are being considered. It has stood the supreme test, the practical test of continuous service satisfactorily. It has made friends continually for itself by its general habit of meeting and satisfying all possible requirements in the line of its work.

We might have what we might call tests of the bodily performance of different animals as compared with the human machine, and according to the function which was given prominence and made the basis of the individual test a hundred different animals would be separately the victors, yet we find no man on earth who would choose the body of any animal in preference to his own for the sake of the single point of excellence. In himself and with his natural equipment he can do more things and do them with possible satisfaction than would be possible in any other way.—*Cassier's Magazine.*

COMPRESSED AIR LEAKAGE

At the recent New York annual meeting of the American Society of Mechanical Engineers a paper on "Power Service in the Foundry," by Mr. A. D. Williams, of Pittsburg, contained the following paragraph, the italics being ours:

"As generally installed, with a central compressing plant, the use of compressed air requires an expensive transmission line and in addition, *it is impossible to avoid leakage in* *the joints.* Compressed air leakage does not show, and the pipe lines for this purpose, as usually constructed, are designed to remain tight only long enough to pass the acceptance test. Leakage is a continual drain on the system, and shows up in the amount of coal consumed. Except in the large sizes, air compressors are steam eaters like steam pumps; for this reason the small electric driven air compressor presents numerous advantages, as it consumes no power when out of use, and, if portable, avoids the long pipe line."

This made an opportunity for Mr. Frank Richards, who discussed the matter as follows:

"For line piping for compressed air transmission precisely the same pipes and fittings are used as for steam or water, and it is no more difficult to make joints tight, or to keep them tight, for air than for steam or water. In fact, it is much easier to keep air pipes tight than steam pipes, as the same heating and cooling, and the accompanying expansion and contraction stresses, do not occur.

"It might be well for Mr. Williams to step over to the excavation at West Thirty-third street for the Pennsylvania Terminal. He will find there considerable lengths of compressed air pipes running all around the excavation, with branches reaching in various directions to hoists, pumps and rock drills, and if he can find any leaks there he will do what I have not been able to do.

"At the Phillipsburg shops of the Ingersoll-Rand Company all the power transmission is by either electricity or compressed air. There are some miles of compressed air pipes and various air operated devices are employed, both in the foundry and elsewhere, and the pressure left in the pipes at night is found in them next morning.

"The quarry of the Cleveland Stone Company at North Amherst, Ohio, has nine or ten miles of compressed air pipes, all the machinery of that extensive quarry being air driven, and there the piping is 'bottle-tight.' Air leaks are not discoverable because they are not there. Full pressure is found in the receivers after standing 24 hours.

"In the paragraph under consideration we are further told that 'compressed air pipe lines, as usually constructed, are designed to remain tight only long enough to pass the acceptance test.' The compressed air business, just like the other established lines of manufacture represented by hundreds of members of this society, has grown and has prospered not by the passing of acceptance tests, but by all-the-year-round efficiency and reliability after acceptance.

"In this connection it seems to be permissible, if not imperative, to call attention to a record of compressed air practice which is unique. For supplying the compressed air by whose agency the various tunnel enterprises of Greater New York have been carried so nearly to completion, there have been installed, all of them being still in place, eighty air compressors. The combined free air capacities of these compressors amount to 190,000 cubic feet per minute, which volume would be represented by a cube with a side of 57 feet. They develop an aggregate of 40,000 horsepower.

"These compressors as they were erected were almost immediately put to work and if there was any acceptance test in any case the ceremony was generally omitted. The compressors have worked constantly, most of them day and night and always some on Sundays, at speeds never before recorded and with the responsibilities of life and death upon their maintenance of the working pressures; conditions of unusual difficulty and many of them unforseen and unprovided for have developed; there have been accidents and delays innumerable in the progress of the work; all these we have heard of, but not one word of any shortcomings of these compressors.

"The work of building these tunnels, as is well known, was done under the direction and approval of some of the world's most experienced and responsible engineers and by several different contracting companies but every one of these eighty compressors was built by the same manufacturing company. The acceptance test may be said to have been in the completion of the entire task and the triumphal accomplishment of this is in sight.

"We are told in this same paragraph that 'except in the large sizes, air compressors are steam eaters like steam pumps.' The steam driven air compressor of any size is normally a stationary steam engine with its power applied directly to the work of compression and for steam consumption and power development it is always comparable upon equal terms with the ordinary stationary engine of the same type. It may have a plain slide valve with suitable lap, it may have an adjustable cut-off or it may be a completely automatic engine with Corliss or equivalent valve gear, and we may in every case expect the same economy in the compressor as in the stationary engine. The ordinary steam pump of any size has clearances large and uncertain; but certainly large, it uses the steam entirely without expansion, so that the pressure at the end of the stroke is as high as the highest; its piston speed is slow. It is comparable only with itself."

MAGNETIC HOISTS

It looks as if the air hoists long used so successfully in American machine shops will be rivalled by hoisting magnets which are coming into great favor in British iron works. Castings weighing two or three tons are lifted by electro-magnets. Much time is saved in comparison with the use of hooks, slings, and other devices, as the mere throwing of a switch energizes the magnet, and the apparatus is able to hold on without any catching and securing devices.—*Exchange.*

But, bless you, the magnet doesn't do the hoisting. It only grabs the load, and it can only grab iron or steel at that, and for that it's very handy, but air or other power has to do the hoisting, the same as always.

THE ACTUAL CAISSON DISEASE FATALITIES IN THE HUDSON RIVER TUNNELS

We are glad to print the following letter addressed to *The Engineer*, London, concerning the mortality among the workers in the Hudson River tunnels caused by working in compressed air. It is of course authoritative and final, and it should be gratifying to all to know that such care has been taken of the lives of the men employed and that the current stories of heavy mortality prove to be so exaggerated and so widely at variance with the facts.

"Sir—I beg to hand you herewith a letter from our chief medical officer in charge of the Hudson and Manhattan tunnels, as also the Pennsylvania tunnels under the North River, with reference to the statement as to death due to caisson disease in your valuable paper of October 18th, and I shall be glad if you are able to publish the facts as herein stated.

"Since I have taken charge of the construction of these various tunnels, on the initiation of the work I took particular care to protect the men in all reasonable ways possible, and selected Dr. Loomis as the best practical medical man I knew on this subject to take charge of the entire force. He has under him on this work four assistants. I have also given the strictest instructions with relation to the acceptance of men for compressed air work, and I am sure that at least 50 per cent. of the labor offered has been rejected for medical or physical reasons by the examining medical officers, and during their occupation medical supervision is very carefully carried out, as well as other means, in the interest of preservation from fatalities and caisson disease.

"CHARLES M. JACOBS, Chief Engineer.

"Hudson Companies, New York,
"November 8th."

"To Mr. Charles M. Jacobs, Chief Engineer:

"Dear Sir—I desire to call your attention to an article appearing in *The Engineer*, London, of October 18th, 1907, entitled 'Compressed Air and Its Influence on Health,' from which the following is an extract: 'It is a fact that the men who worked in the diving bells at the Dover Harbor works were free from illness in contrast with caisson workers at the same pressure. The sickness among workers in the New York subaqueous tunnels is considerable, and in the Hudson tunnel works eight men died in six months last year.'

"Since the resumption of work on the Hudson River tunnels in 1902 I have been in charge of the medical department of that work, as well as that of the North River division of the Pennsylvania tunnels, which comprises the whole of the subaqueous tunnels in connection with the North or Hudson River.

"During that time there has been constructed in round numbers 41,800 linear feet of tunnel under the river itself or its filled-in banks. In this work my records show that there have been examined for work in pressures varying from 15 pounds to 42 pounds over 21,000 men. Of that number there were no deaths from compressed air sickness in the Pennsylvania tunnels—12,000 feet—and but two in the Hudson Companies tunnels.

"This is such a flagrant misstatement of facts that I feel in justice to the work and myself, I cannot allow it to pass without protest.

"I respectfully beg of you, as chief engineer of all the tunnels building under the Hudson

River, otherwise known as the North River, to transmit the above facts to the editor of *The Engineer,* London, for his very kind consideration in the matter. Yours truly,

"A. J. Loomis, M. D.,
"Chief Medical Officer."

QUESTIONS AND ANSWERS

F. C. S., Toledo.—*Q.:* If 150,000 cubic feet of air enter a downcast shaft 16 feet in diameter at a temperature of 55 degrees F., what must be the diameter of the upcast shaft to pass this air at the same velocity when the temperature of the upcast is 105 degrees?

A.: With the pressure constant, as it may be assumed to be in this case, the volumes will be directly as the absolute temperatures. These temperatures being $55+461=516$ and $105+461=566$, and the areas or capacities of the shafts being directly as the squares of their diameters we have the following proportion:

$516:566::16^2:280.8$ and $\sqrt{280.8}=16.75$ feet or 16 feet 9 inches.

J. A., Knowles, Cal.—*Q.:* A two-stage air compressor with the low pressure cylinder 18¼ inch diameter and the high pressure 11¼ inch, with a common stroke of 14 inch, compresses air to 100 pounds, gage; what pressure should be maintained in the receiver between the cylinders?

A.: The receiver or intercooler pressure, and the consequent intake pressure of the high pressure cylinder, in this case is determined by the relative capacities of the two cylinders and remains constant whatever the terminal pressure of the high pressure cylinder. Both cylinders of this compressor being of the piston inlet type, as indicated by the addition of the ¼ inch to the nominal diameter of each to compensate for the displacement of the piston inlet pipe, the effective diameters may be assumed to be 18 and 11 inch respectively. Then the intake pressures (absolute) of the two cylinders will be inversely as the squares of their diameters, always assuming that the intercooler delivers the air to the high pressure cylinder at the original temperature. Then we have: $11^2 : 18^2 :: 14.7 : 39.36$ and $39.36 - 14.7 = 24.66$ gage pressure for the intake of the high pressure cylinder. It is desirable to have the compression ratios in the two cylinders as nearly alike as possible in order to equitably divide the work. In this case the compression ratio in the low pressure cylinder is $14.7 : 39.36 = 0.3734$, and in the high pressure cylinder it is $39.36 : 114.7 = 0.3431$, which is as near as could well be wished. While we are on this compressor it may be worth while to note and compare the power required for single-stage and two-stage compression. We assume a piston speed of 300 feet per minute in each case. The mean pressure per stroke for adiabatically compressing from atmosphere to 100 pounds gage, 14.7 to 114.7, being 41.6 (Richards' Compressed Air), we have $18^2 \times .7854 \times 41.6 \times 300 \div 33,000 = 106.24$ horse-power for single-stage compression. For two-stage compression, the compression in the low-pressure cylinder being from atmosphere to 24.66 pounds gage, say 25 pounds—it would really be a little more than that on account of the friction in passing through the intercooler and connecting passages—would be: $18^2 \times .7854 \times 17.01$ (m.e.p.) $\times 300 \div 33,000 = 39.35$ horse-power. Then for the high-pressure compression from 24.66 to 100 gage (39.36 to 114.7 absolute) the mean effective unbalanced pressure per stroke being 49.34 the horse-power will be: $11^2 \times .7854 \times 49.34 \times 300 \div 33,000 = 42.63$, and $42.63 + 39.35 = 81.98$, say 82, total horse-power for two-stage compression. As we found the horse-power required for single-stage compression to be 106.24 the additional percentage of power thus required would be $106.24 \div 82 = 1.295$, or 29½ per cent. In practice probably a saving of 25 per cent. might be realized by the two-stage compression. The more important advantage really in two-stage compression to pressures approximating 100 pounds is in the avoidance of damaging and dangerous temperatures. The theoretical final temperature attained in compressing by single stage from atmosphere to 100 pounds and from initial temperature of 60 degrees is 485 degrees, while in two-stage compression the highest temperatures possible would be 234 degrees in the low-pressure cylinder and 249 in the high-pressure cylinder, these temperatures all affected and held down to some extent by the water jacketing.

W. M. S., Botson, Tex.—*Q.:* I find in a certain "Pocket Book" the following example and solution:

Example: In a compressed air plant the gage shows a pressure of 80 pounds per square inch; the area of the piston is 20 square inches, and its stroke 10 inches. The pump makes 100 strokes per minute; assuming that there is no leakage of air past the piston, what will be the volume of air discharged from pump into the mine per minute?

Solution: The volume of air discharged from the pump cylinder per minute $= \frac{20 \times 10 \times 100}{1728} = 11.57$ cubic feet (cylinder pressure). The absolute pressure on the air in the cylinder is $80 + 14.7 = 94.7$ pounds. The absolute pressure on the discharged air is simply the atmospheric pressure (14.7). Hence we write the proportion 14.7 : 94.7 :: 11.57 : and working this out we have $94.7 \times 11.57 \div 14.7 = 74.54$ cubic feet per minute, nearly.

Now, what I do not understand is this: if the piston has an area of 20 square inches and the stroke is 10 inches the piston will displace or compress 200 cubic inches per stroke, and making 100 strokes per minute the total amount of free air handled will be 20,000 cubic inches, or 11.57 cubic feet.; how then can there be any more air delivered into the mine even though the pressure be 80 pounds, and is not the quantity discharged into the mine 11.57 cubic feet, instead of 74.54 cubic feet, and, if not, why not?

A.: There seems to be a little misunderstanding in this case. The cylinder spoken of is not a compressor cylinder, but the cylinder of a steam pump in which compressed air is used to drive the pump instead of steam. The cylinder is filled at each stroke with air at 80 pounds pressure, or 11.57 cubic feet at that pressure, for the 100 strokes, and when this air is discharged into the atmospheric pressure of the mine the volume becomes, after the temperature is equalized, 128,843 cubic inches, or 74.56 cubic feet. Of course when the usual clearance and other losses were allowed for the volume would actually be 25 to 50 per cent. larger than this.

TRADE PUBLICATIONS

Wrought Iron Pipe vs. Steel Pipe, Reading Iron Company, Reading, Pa.; 14 pages, 6x9 inches. This is the sixth edition of a pamphlet first printed in 1906. It makes a strong argument for and cites numerous authorities as to the superior endurance and longevity of wrought iron pipe in competition with modern steel pipe.

Boiler, Ship and Structural Rivets, The Champion Rivet Co., Cleveland, Ohio; 78 pages, 6x9 inches. Reports of elaborate tests are given with various other valuable information concerning "Victor" rivets manufactured by the above firm, and a considerable number of large and excellent half-tones are given showing structures in widest variety in which Victor rivets were used.

Storage Batteries for Portable Service, The Westinghouse Machine Company, Pittsburg, Pa.; 32 pages, 6x9 inches. This publication is devoted to a new line of manufacture of this company. There is no text to distract or weary the reader. The various types of batteries with every detail are shown by excellent half-tones and copious information is furnished entirely in tabulated form.

COMPRESSOR AND DRILL PRACTICE ON THE RAND

The following was written by a special correspondent—name not given—to *The South African Mines.* It contains nothing of information or advice of any value or pertinence to American miners—what do we know of the low pressures, the leakages, the all-round inefficiencies here spoken of?—and it is only reproduced here as giving a realization of the loss in regions supposed to be at least in touch with us and to know not only of our means and methods but also of our rate of working and accomplishment. When will there be a waking up, and who is to do the awakening?

"A series of tests recently made on these fields has demonstrated beyond a doubt that with compressed air at 60 pounds pressure at the rock drill, a good 20 per cent. more work can be done than with only 50 pounds, and that with 70 pounds air pressure the work done by the rock drill is a good 40 per cent. greater. What would have been done with 80 pounds air pressure, such as the American and Australian miner is accustomed to, could not be determined because none of the mines on the Rand carry it underground.

AIR LOSSES.

"The loss due to leaky pipes is admittedly not inconsiderable. The real air loss, however, is not in volume, but in pressure, *i. e.,* friction due to small pipe lines accounts for 90 per cent. of the bad air pressures encountered underground. For instance, there is a 3 pounds loss in pressure due to feeding air to rock drills through 50 feet of one-inch air hose. Add 50 feet of one-inch air pipe and the total loss in pressure is 7 pounds. The loss in the average drive pipe line is rarely under 10 pounds, and frequently 20 pounds. Deduct all these friction losses from the 70 to 75 pounds pressure in the engine-room, and it is not difficult to see where the air, coal, and money goes.

ICE V. ROCK.

"The rock drill on the Rand not only has to put up with bad air pressures, more often under 50 pounds than over, which is often the fault of the mine management, but also has to contend with a great deal of moisture in the compressed air, due as a rule to faulty construction of the air compressors and failure to provide an air after-cooler, or in lieu of this, large enough air receiver capacity on the surface and sufficient water traps underground. The efficient rock drill underground overcomes this disability, but some makes of drills labor under it badly, in that their exhaust ports are improperly proportioned and the machine designed to drill rock becomes a most efficient ice machine. As the miner does not get credit for the ice thus produced he takes a most violent prejudice to such machines, and quite rightly, because an ice machine is no good for drilling rock.

UNDERGROUND SURPRISES.

"Recently a manager of one of the groups detailed a man to go down the night shift and make a report on the air pressures underground. Quarter-hour readings taken all over the mine during the shift showed something like 40 pounds air pressure. At another mine, of another group, the consulting engineer admitted an underground air pressure of only 55 pounds, the 20 pounds excess in the engine room being accounted for by pipe line friction. The manager of a mine belonging to a third group discovered that by substituting a 2-inch pipe line for a 1¼-inch line, he secured 15 pounds higher pressure at his drills, the machines then doing in one shift what had previously taken two shifts to do. On a mine belonging to a fourth group the "air report" handed in gives the air pressure at 70 to 80 pounds in the engine room, whereas an average of 65 is more correct; underground it is 45 to 50.

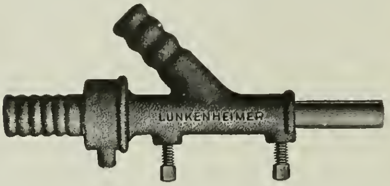
DRILL BITS.

"The demand for low costs has brought about the use of a cheaper steel, *i. e.*, instead of using a sixpenny a pound steel, the prevailing grade bought is sold for about a third, and in some cases, a half less. This would not be so bad in itself if proper care was taken in forming and tempering the bits. But in too many cases they are so badly formed as to "rifle" or "fitcher" in the hole, which creates a use for the inevitable 10 pound sledge hammer and "sprains" some of our machine drill costs. In other cases, just as frequently bad tempering leaves the drill bit so soft that it is dull after the first few minutes work, and then proceeds to chew up air at the rate of halfpenny per minute, doing practically nothing. With the mines furnishing the hoped-for 70 to 80 pounds air pressure, and the makers alive to the fact that rock drills and not ice machines are wanted on these fields, it will probably be found desirable to use a higher grade of steel to bear the increased power and do the larger amount of work expected therefrom. Quality, not price, will then be the chief consideration, especially if we temper with temperatures instead of colors. Due to poorly formed and badly tempered drill bits, the average mine on the Rand is compressing at least 25 per cent. more air per shift than necessary. Carrying the argument to its logical conclusion, we find that cheap drill steel and poorly formed and badly tempered bits cost the industry as a whole something like fourpence per ton of rock hoisted more for air power alone than if good drill bits were used. Underground air pipe lines of too small a diameter account for our wasting 20 per cent. of the coal used to compress air for rock drill purposes. If this assumption is correct, it is costing the industry another fourpence a ton more for rock broken by machine drills than it should, due to air lines being too small.

LEAKY PIPES AND BAD AIR PRESSURES.

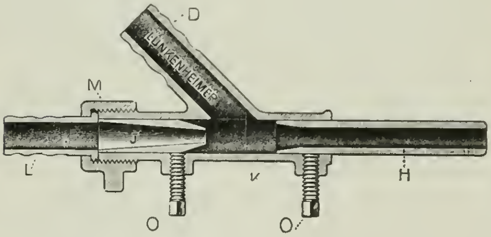
"To keep 2,200 rock drills supplied with compressed air costs about a half-million sterling, and if only 10 to 15 per cent. is lost through leaky pipes the loss is £50,000 to £75,000 per annum, or 1½d to 2d per ton of rock broken by machines. With 40 to 55 pounds air pressure something like 5,000,000 holes are drilled here, with machines, per annum and cost about £1,300,000 for labor alone. Increasing the pressure at the working faces to 70 pounds would increase the capacity of the machine drills about 40 per cent. or reduce the cost per ton by about 9d. This is what is lost to-day.

IMPROVED SAND BLAST NOZZLE



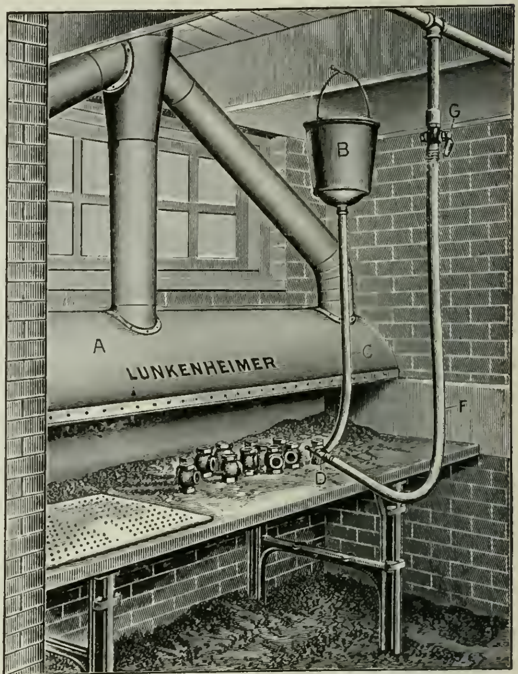
We show on this page an improved sand blast nozzle made by the Lunkenheimer Company, Cincinnati. The most troublesome feature of the sand blast apparatus has been the rapid wearing of the outlet tubes. This is said to be overcome in the present device by the special hardness of the metal employed. Attention is called to the internal shape of the air tube J. The shape here adopted is found to not only give greater force to the impinging particles, but the result is accomplished with a reduced air consumption. The body K, tail piece L and union M are made of a hard, high-grade bronze. The wearing parts, outlet tube H and air tube J, can be readily and cheaply renewed.

To secure the best results it is recommended that a pressure of from 60 to 100 pounds be carried, the tubes being adjusted to suit the pressure. The higher the pressure the nearer they should be brought together, and they are easily secured by the set-screw O.



It is claimed for the nozzles here shown that from 30 to 50 per cent. more castings can be cleaned by them than by the means usually employed. The smallest corner can be easily reached, and when the blast is applied to brass castings an effect is produced which resembles wire brushing.

The larger illustration shows a sand blast room in which this nozzle is employed. Here on the bench are a lot of small castings with complicated cores. The room is partitioned off by itself. A hood A is fixed above the bench and to the hood is connected a suction pipe which carries off the sand. It may be gathered in a settling chamber and used over again. A reservoir B for the sand to be used is suspended in a convenient position and a hose C leads to the nozzle, and the sand descends by gravity. A hose F connects with the air supply and a valve G turns it on or off as desired.



Sandblasting Small Castings.

NOTES

The four deepest mine shafts in the world are in the Lake Superior copper region within a mile of each other. These are the Red Jacket shaft of the Calumet & Hecla Company and shafts Nos. 3, 4 and 5 of the Tamarack Company. The first is vertically 4,920 feet, and the Tamarack No. 5 is a vertical shaft 5,130 feet deep.

The imperial statistical bureau in Berlin has just published the result of a census of the professions, trades and occupations pursued in the empire. The complete list includes 15,016 items. Some of the callings have tens of thousands of followers. In many cases there are only a few. The list illustrates the German love of accuracy and also the capacity of the language for exact titles. One man, for instance, is set down as Forstshutzdienstanwarter, which means candidate for the forest protection service. The climax of title is reached in the somewhat numerous and somewhat humble group who are described as Eisenbahnbetriebstelegrapheninspektionsassistenten. These are the assistant inspectors in the railway telegraph service. One man makes his living by *renting out compressed air.*

Speaking of gas heated core ovens ("gas fired core stoves") Mr. A. R. Bellamy, before the Manchester Association of Engineers, spoke of a novel method of determining when the contents of an oven were quite dry. The difference of temperature between the gases when entering the oven and when leaving is due to the heat given up to the cores plus a constant amount for radiation, etc. When, therefore, the cores are quite dry the difference between the temperature of the gases on entrance and exit would decrease and finally become constant. Two thermometers would, therefore, enable the time to be easily determined when the cores were all dry.

A new and very successful method to prevent infiltration of water in walls and the soil is described by "Elettricita" of November 1. Compressed air is conveyed into a vessel furnished with a mixer containing lime or cement well diluted. To inject the cement, a flat-nosed fire-hose nozzle is employed. The nozzle is applied against the wall or the earth, and gradually moved over all parts. Special attention is given to the arched parts of vaults and points of contact with the soil. The cement thus injected gradually sets, forming a single piece with the main work, increasing its strength and preventing all chance of infiltration.

One of the engineers of the Cleveland water department, who assisted in the construction of the Cleveland water tunnel, believes that he has discovered in compressed air the cure for consumption. He has arrived at this conclusion after watching the effect of compressed air on men at work under it. He declares that one consumptive was completely cured and that many men whom the engineers were afraid to place under compressed air because of weakness, thrived upon it. In the New York tunnel he claims that physicians have also found consumptives improving. A number of practical tests are to be made.

It is said that a bullet fired by a charge sufficient to give it an initial velocity of 1,700 feet a second in dry weather would travel no more than 1,300 feet through moist air.

This is an irresponsible paragraph which cannot possibly be true. The *initial* velocity in either case would be practically the same, as that would be imparted to the bullet before the resistance was begun to be encountered. Definitions would be required as to what was dry air and what moist air. Moist air would be dry air at a higher temperature, and *vice versa.*

The town of Thompson Falls, situated along Clark's Fork River and in proximity to the falls of the stream, is built upon gravel ground. Some years ago one of the early settlers started the sinking of a well on the river bank and was astonished to find a cold wind of some velocity coming up out of the gravel after the well-hole was down about 40 feet. This wind, or "breath from mother earth," was ice-cold; he continued the well to 60 feet depth and secured a large flow of ice-cold, clear water; the cold air continued to flow out of the well, and the well-digger found that he could, by placing a grate at the top of the well, utilize the cold air for refrigerator purposes. Since that time many other wells have been dug and all give the same result. By running a pipe of about one foot in diameter from the side of the wells to the adjoining store and house cellars the buildings are kept delightfully cool during the hottest weather. Perishable foodstuffs are better preserved than when placed in ice refrigerators. In the winter it is necessary to batten the doors and wrap the pipes; also, to thoroughly protect the wells, else the water in the bottom of the wells will freeze into a solid block of ice as a result of the cold air.—*Mining Reporter.*

The annual report of the British Weights and Measures Association records steady progress in the task of defending British weights and measures against the attacks of the advocates of the metric system. The association is supported by representatives of all indus-

At the end of 1904 ten tons of diamonds, valued at $300,000,000, had been taken out of the Kimberley mines. It is difficult to imagine what has become of them all, and, since they are durable and permanent, how the demand for them keeps up. Twelve years ago about twenty million dollars a year was spent for diamonds, and now the expenditure is larger.

It is less than a decade since the first steam turbine was sold in the American market, but there are to-day about 700 in use throughout the country, aggregating a total capacity of approximately 1,000,000 kilowats or about 1,500,000 horse-power. An interesting test was conducted recently by the engineers of the New York Edison Company at the Waterside station near Thirtieth street. The unit under test was a Westinghouse turbine of 10,000 horse-power. It had been sold under a steam consumption guarantee of 15.9 pounds of steam per kilowatt hour, but the test recorded the phenomenally low steam consumption of a shade less than 14.9 pounds per kilowatt hour, the lowest record for steam consumption which has ever been recorded by a stationary steam engine.

Theoretically, a miner working underground requires only 6½ cubic feet of fresh air per minute for respiration and the absorption of moisture and the dilution of carbonic acid gas. This assumes that air after having been breathed is immediately removed without mixing with the surrounding atmosphere, a condition impossible to fulfill. Considering that the permissible vitiation of air by carbonic acid is six parts in 10,000, it will be found necessary to provide 66 cubic feet of air per minute to dilute and carry away the 0.8 cubic feet of carbonic acid produced per hour by one man. Considering the problem in this light, it is evident that, although an average man at work breathes only about 750 cubic inches of air per minute, the amount necessary to carry away the gases given off is the important consideration.

The largest diamond so far known was found at the Premier mine, in the Transvaal, in January, 1905. It weighs 3024.75 karats (9582.4 grains, very nearly one pound six ounces). It is an irregular prolate spheroid about four inches long. It is supposed to be a fragment of a much larger stone.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissione of Patents, Washington, D. C.

NOVEMBER 5.

869,893. HYDRAULIC ROCK-DRILL. Georg E. Gjuke, Trelleborg, Sweden.

In a device of the class described, a cylinder, a piston, a fluid pressure chamber on the axial line and to the rear of the cylinder in communication with the rear portion of the cylinder, and means actuated by the piston for drawing atmospheric air into the fluid pressure chamber upon the working stroke of the piston and compressing it therein upon the rearward or back stroke.

869,909. ANEROID BAROMETER. Adolph E. Kahn, New York, N. Y.

869,925. PRESSURE-GAGE. Daniel M. Moore, Newark, N. J.

869,930. AUTOMATIC AIR-BRAKE APPARATUS AND METHOD. John T. McIntosh and James S. Manton, Chicago, Ill.

869,966. PROCESS FOR COMPRESSING AND PURIFYING AIR. Willard O. Felt, New York, N. Y.

870.167. AIR-INSPIRATOR. John Heimlich, Port Clinton, Ohio.

870,178. HAMMER-DRILL. Alfred E. Johnson, Denver, Colo.

870,190. ACETYLENE-GAS MACHINE. Louis H. Miller, Campbell, Cal.

870,325. PNEUMATIC RENOVATOR. Jfhn S. Thurman, St. Louis, Mo.

870,523. PNEUMATIC TOOL. Owen W. Thomas, St. Paul, Minn.

NOVEMBER 12.

870,546. AIR-DRIER FOR DESICCATING APPARATUS. Ernest W. Cooke, New York, N. Y.

870,630. MEANS FOR CONTROLLING FLUID-PRESSURE. Frank E. Kinsman, Plainfield, N. J.

870,651. FLUID-PRESSURE-OPERATED TOOL. Henry H. Vaughan, Chicago, Ill.

870,659. VALVE FOR PUMPS, COMPRESSORS, AND THE LIKE. Hugo Ackermann, Berlin, Germany.

870,806. FLUID-PRESSURE BRAKE. Walter V. Turner, Edgewood, Pa.

870,891. AUTOMATIC GAS-CONTROLLER. Joseph C. Landes, Collegeville, Pa.

870,981. VACUUM CLEANING SYSTEM. Frank J. Matchette and Richard Raddatz, *Milwaukee*, Wis.

871,079. MEANS FOR INCREASING THE AIR-BLAST OF CONVERTERS AND FURNACES. Ralph Baggaley, Pittsburg, Pa., Charles M. Allen, Lo Lo, Mont., and Edward W. Lindquist, Chicago, Ill.

871,086. ENGINE. William O. Duntley, Chicago, Ill., and George H. Hayes, Philadelphia, Pa.

NOVEMBER 19.

871,164. AIR-SHIP. Amos C. Ellsworth, Newport, Vt.

871,186. PNEUMATIC EQUALIZER FOR VEHICLES. Chaim Rosenzweig, New York, N. Y.

871,194. HUMIDITY-REDUCING APPARATUS. Richard H. Thomas, Chicago, Ill.

871,209. JET BLOWING APPARATUS. Alrfed Cotton, Newark, N. J.

871,277. PRESSURE-REDUCING VALVE. Andrew T. Johnson, Tonopah, Nev.

871,292. TURBINE COMPRESSOR, PUMP, AND THE LIKE. Charles A. Parsons and Alfred Q. Carnegie, Newcastle-upon-Tyne, England.

871,350. PERCUSSION-DRILL, &c. Bradford H. Locke, New York, N. Y.

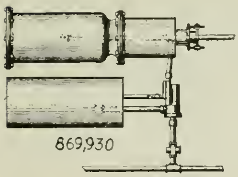
871,360. ELECTRIC AND PNEUMATIC GOVERNOR. William K. Rankin and Thomas F. Kelly, Philadelphia, Pa.

871,391. PNEUMATIC GATE. William P. Elliott and William P. Elliott, Jr., La Grange, Ill.

871,508. GAS-ENGINE. John Houlehan and William C. Mayo, El Paso, Tex.

In an internal combustion engine having a power cylinder provided with an explosion chamber and means for introducing the explosive mixture and ex-

869,893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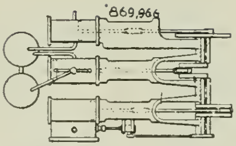
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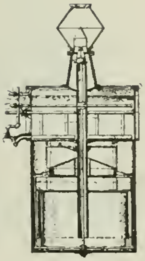
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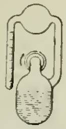
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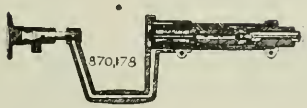
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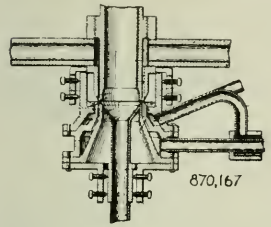
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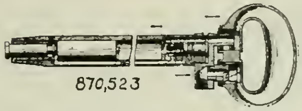
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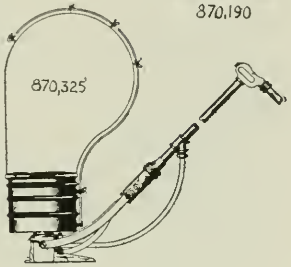

870,325

Pneumatic Patents, November 5.

hausting the burned gases, a compressed air reservoir, means for establishing and cutting off communication between the said reservoir and the explosion chamber of the engine, a movable member forming the rear wall of the explosion chamber, and means for adjusting said movable member to cut off communication between the explosion chamber and the intake and exhaust means.

871,594. ROCK-DRILL. Edward N. Jones, Victor, Colo.

871,626. TURBINE AIR-COMPRESSOR. Enos C. Pollard, Seattle, Wash.

871,656. HYDROCARBON-BURNER FOR FURNACES. Burt L. Worthern, Tucson, Ariz.

871,756. VALVELESS PNEUMATIC TOOL. Frederick S. Graham, Philadelphia, Pa.

NOVEMBER 26.

871,816. VISE. John E. Osmer, Chicago, Ill.

871,910. PNEUMATIC THREADING DEVICE FOR SPINNING-MACHINES. Frank A. Breeze, Philadelphia, Pa.

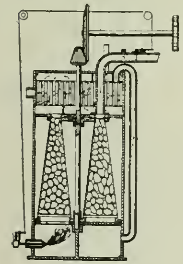
871,926. AIR-PROPELLER FOR FLYING-MACHINES. Louis Gathmann, Washington, D. C.

871,939. PORTABLE PNEUMATIC DRILL. Henry J. Kimman, Cleveland, Ohio.

871,973. MULTIPART MOLD FOR PNEUMATIC TIRES. Friedrich Veith, Veithwerk, near Höchst, Germany.

872,026. DEHYDRATING APPARATUS. Frank T. Stare, Waukesha, Wis.

In a dehydrating apparatus, the combination with a chamber in which the material to be treated is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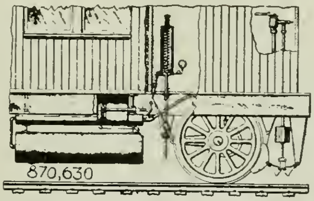
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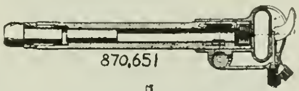
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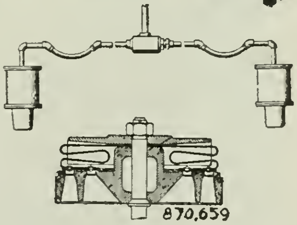
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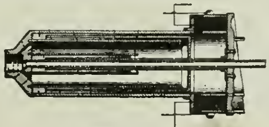

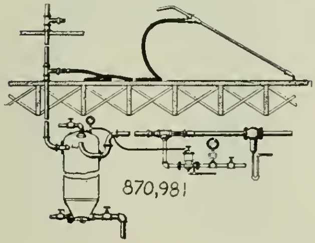
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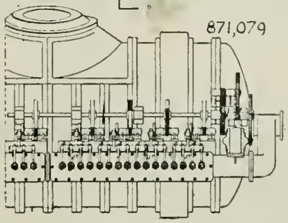
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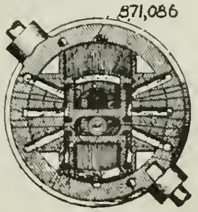
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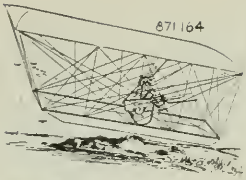
Pneumatic Patents, November 12.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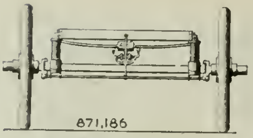
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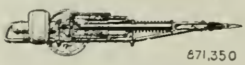
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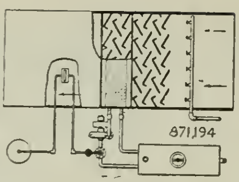
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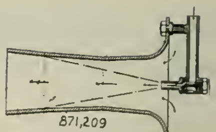
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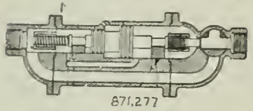
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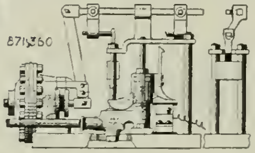
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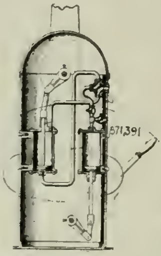
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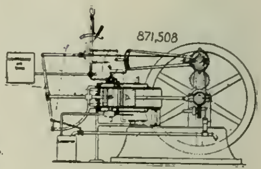
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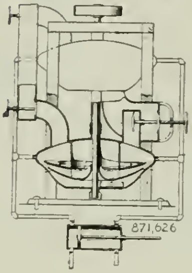
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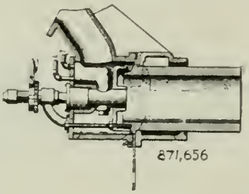
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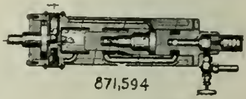
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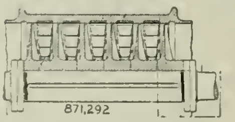
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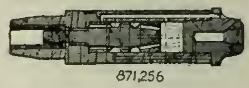

871,256

Pneumatic Patents, November 19.

placed, a condenser and an air drier, of means to maintain a current of air flowing through said chamber, condenser and drier and means to reverse the direction of the current of air through said chamber.

872,043. AIR-PUMP. John C. Beck and John A. Bowyer, Chicago, Ill.

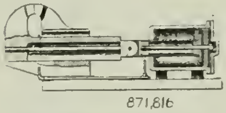
872,054. AIR-DRIER. Ernest W. Cooke, Waukesha, Wis.

872,055. ELASTIC-FLUID TURBINE. Gustaf Dalen, Stockholm, Sweden.

872,273. GAS-PRESSURE REGULATOR. Adelard D. Brasson, San Francisco, Cal.

872,288. LIQUID-FUEL BURNER. John H. Koons, Anderson, Ind.

872,314. PIOC9SS OF R9MOVING PAINT AND VASNISH. John M. Wilson, Montclair, N. J.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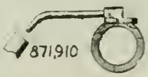
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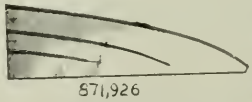
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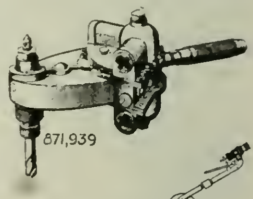
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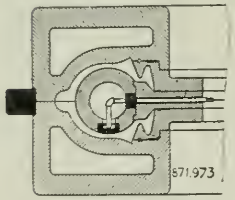
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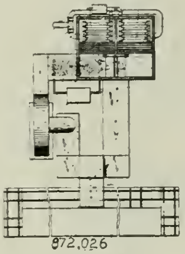
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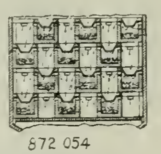
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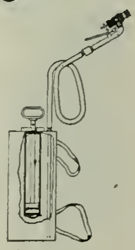
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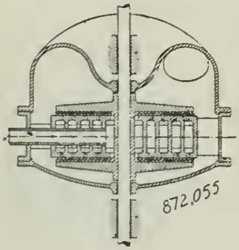
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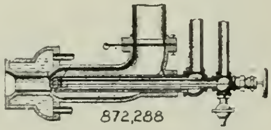
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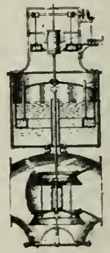
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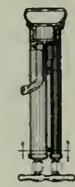
872,043

Pneumatic Patents, November 26.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. xiii FEBRUARY, 1908 No. 2

THE LARGEST PLANER

The largest and heaviest metal working planer ever built, recently completed at the Philadelphia Bement-Miles works of the Niles-Bement-Pond Company, for Mackintosh-Hemphill Company of Pittsburg, is not only of interest as a whole to all who have to do with machine construction and operation but possesses special features for the consideration of the readers of Compressed Air.

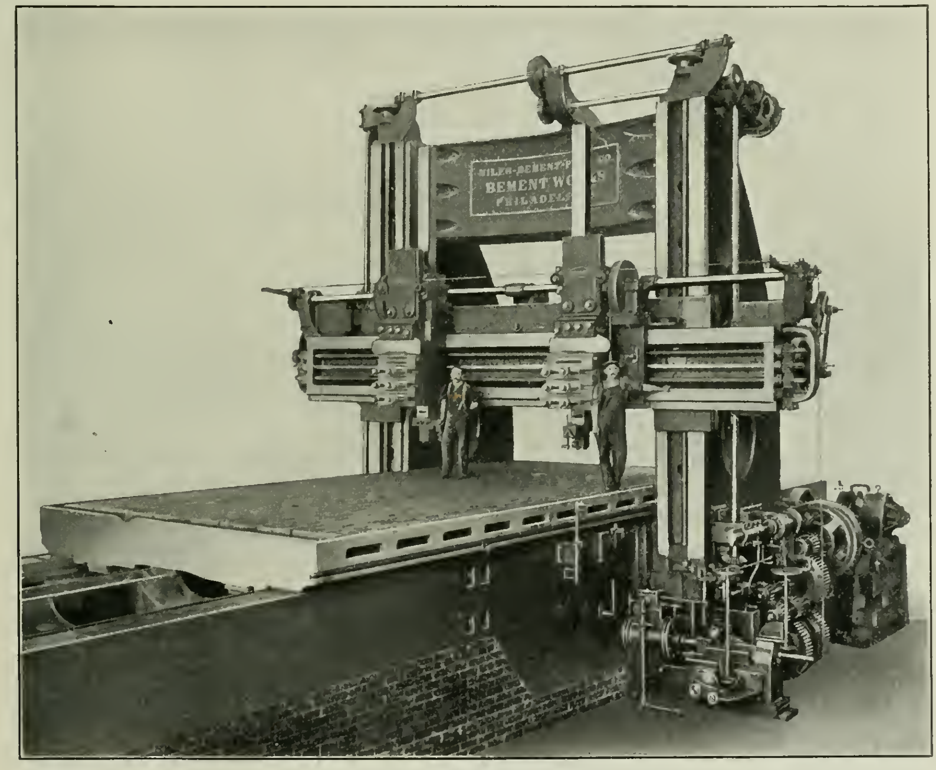

Fig. 1. Front of Planer.

This is a special machine not only as to size but in many of its details. It is, in fact, a combination machine, doing not only regular longitudinal planing but also cross and vertical planing or slotting. That it should be presumably profitable both to build and to purchase and use such a machine as this is a striking evidence of the growth of the business of machine and engine construction, not only as to the size of the units produced but also as to the number of them to give sufficient employment to such a machine. It is to be used for machining heavy engine beds, rolling mill forms, etc., the first job which came to it being a bed weighing 94 tons.

The total weight of this planer is 845,000 pounds, or 422 tons, and it requires a total of 207 horse-power in the motors for the main drive and the several operating or auxiliary movements to be provided for. The distance between the uprights is 14 feet 4 inches, and from the top of the platen to the under side of the cross rail is 12 feet 2 inches. The longitudinal travel is 30 feet. The motor for the main drive is 100 horse-power, this power being transmitted by gearing to reversing pneumatic clutches of the well-known Niles-Bement-Pond type. These clutches are usually operated from a shop air supply but in this instance a compressor with a 30 horse-power motor is a part of the machine. A small valve easily operated controls the starting, stopping and reversing. Tripping this valve by the familiar table dogs gives the automatic reverse to the reciprocating movement.

The pneumatic feed, which is a novel feature of this machine, calls for special mention. This feed has fewer parts and greater strength than the usual mechanical feed. The application of this feed to the crosshead may be clearly seen in Fig. 2. On the side of the upright just above the gearing is a horizontal cylinder with piston rod extending to the left. This rod slides a rack which meshes with a gear near the bottom of the vertical feed shaft. This feed shaft has on its lower end a bevel gear meshing with a bevel gear on a cross horizontal shaft which transmits motion to a vertical feed shaft on the other side of the machine. The movement of these feed shafts is constant under all conditions, and variation in the amount and direction of the head feeds is obtained by adjusting the connecting rods in the slotted cranks on the ends of the cross slide. The feed cranks are so graduated that very precise movements of both the vertical and the cross feeds are produced and combinations of these thus give angular feeds, the heads not being made to swivel. The valve for controlling the air operating the feed cylinder is moved automatically at each end of the stroke, this movement being taken from either the main driving gear train to the platen, or the slotter gearing when slotting. To disengage the feed it is simply necessary to close a valve and shut off the air.

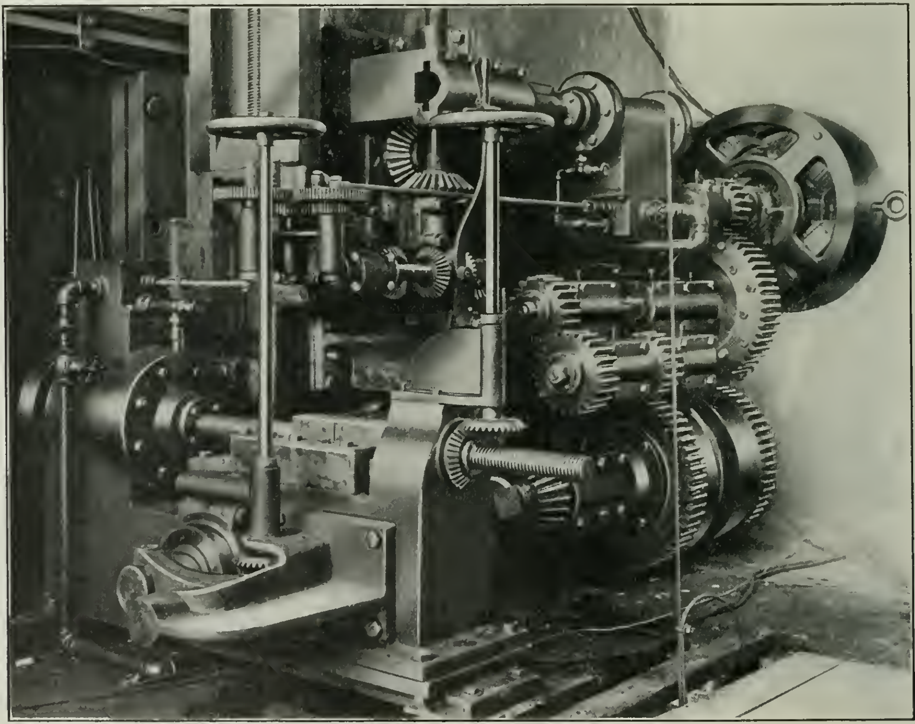

Fig. 2. Pneumatic Feeds of Planer.

The feed mechanism for the table which is required when slotting or cross-planing is seen in Fig. 1 directly in front of the base of the upright. This feed operates practically the same as the feed for the crosshead, except that variation in the amount of feed is obtained by an adjustable stop which limits the piston movement. This adjustment is made by the hand wheel at the right, the hand wheel at the left connecting this feed mechanism to the main driving works.

Fig. 3 shows the base of the left hand upright with the 50 horse-power motor for slotting and cross-planing, and the pneumatic clutch and reversing mechanism. Just above the motor is seen the reversing disc for both slotting and cross-planing. The dogs on the periphery can be set to give any stroke. Bevels on the vertical square shaft above the cross rail, not here seen, are used for changing the drive from slotting to cross-planing.

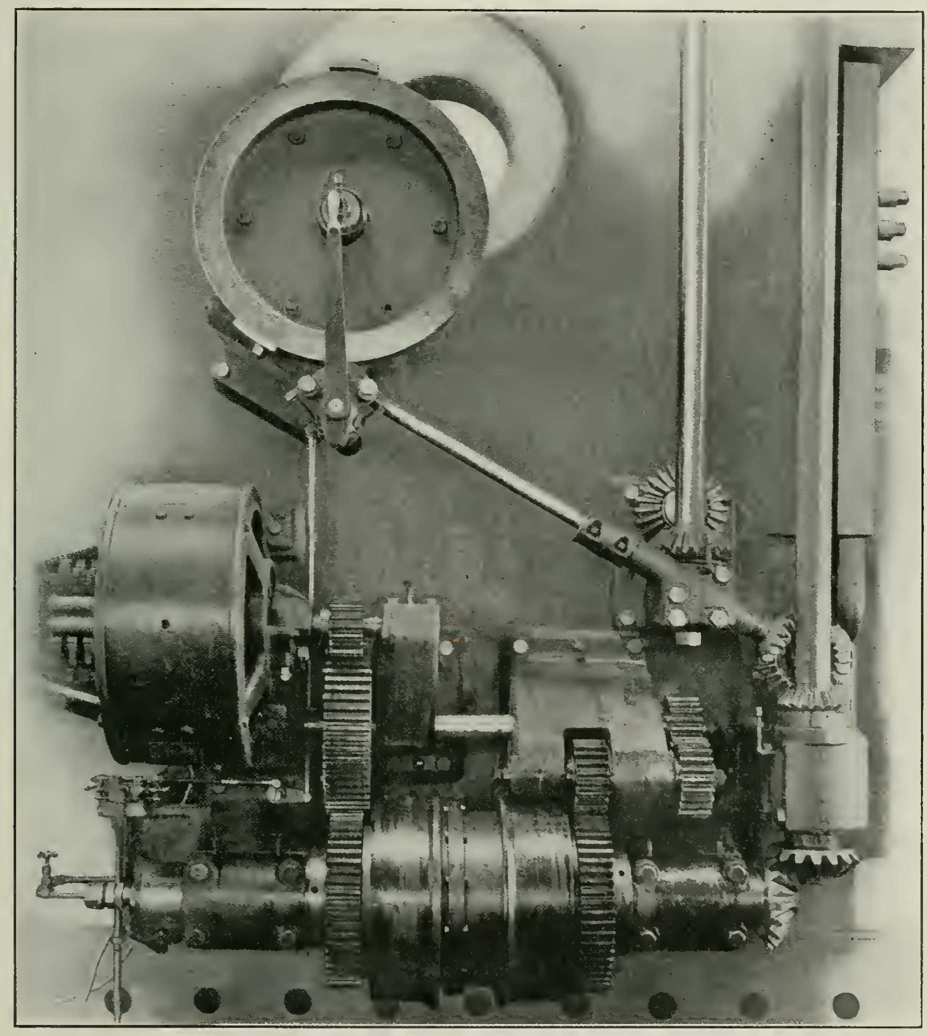

Fig. 3. Motor for Slotting and Cross Planing.

The planer, as was said, has its own compressor driven by a 30 horse-power motor and maintaining a constant pressure in a large storage reservoir, thus making it independent of a shop supply, which, however, may be connected for emergent use. The table is 32 feet long, 14 feet wide, and slides on three ways each 15 inches wide, the center way being an obtuse vee and the outside ways flat. The holes in the top of the table for stops, bolts, etc., extend entirely through the upper plate, below which is a second plate without openings for catching the chips, which may be raked out through the holes in the sides.

The bed is 60 feet long, 13 feet wide and the central part is 73 inches deep. In the ways of the bed are oil pockets and rollers for lubricating the table; one pocket is centrally placed and all are connected to maintain a common oil level. The central section of the bed is divided longitudinally into three parts and the two end sections each into two parts. The total weight of the bed is about 275,000 pounds. The table is divided longitudinally in the center and weighs 140,000 pounds.

THE TUNNEL AND RIVER SHAFT OF THE DETROIT WATER WORKS*

By James Ritchie.

Before making a contract for this work the city of Detroit had built a tunnel from the pumping station to a point near the bank of the Detroit River, a distance of about 1000 feet, and had constructed a gate chamber and a shore shaft with 50 feet of river tunnel. The shore tunnel was 10 feet inside diameter and was placed with its axis at a distance of 26 feet below the surface of the ground. The shore shaft had an inside diameter of 10 feet and a total depth below the surface of the ground of 78 feet 6½ inches. The axis of the river tunnel was at a distance of 69 feet below the surface of the ground, or 63 feet below the surface of the water in the Detroit River. The inside diameter of the river tunnel was 10 feet, and the tunnel was constructed of four rings of shale brick laid in Portland cement mortar. The diameter of the excavation was 13 feet. After completing the first 50 feet of the river tunnel, the city put in a timber bulkhead and prepared to let a contract for the rest of the tunnel, the river shaft and the intake crib and crib house.

The contract for the river tunnel and shaft covered 3,185 feet of tunnel from the end of the 50 feet built by the city to a point 75 feet beyond the center of the intake crib, and a river shaft of 10 feet inside diameter placed at the center of the crib. The end of the tunnel was finished by two bulkheads 25 feet apart, to permit of a second crib and shaft being constructed should it be determined to extend the tunnel.

Work was commenced on the ground at the shore shaft on May 1, 1904, and consisted of setting up the machinery, building engine and boiler house, cement shed and offices, installing the elevator supports and preparing for the work of construction while awaiting the arrival of the materials. The power plant consisted of two boilers, one Ingersoll and one Rand air compressor, each 18 by 24 inches, one electric generator and engine for operating same, one elevator hoisting engine, two drainage pumps for removing water from the tunnel and one boiler feed pump.

On June 14, 1904, we commenced laying brick, and continued without using compressed air until we had completed about 40 feet, when work was stopped in order to install the air locks. These were two in number, the working lock being 5 feet 6 inches in diameter and 22 feet long, set on the bottom of the tunnel and enclosed in brickwork and cement, and the emergency lock above the working lock, to be used in case of accident. The emergency lock was at all times open to the tunnel, so that if the working lock were closed the men could escape any danger by entering the upper lock, closing the door and locking out towards the shore shaft. Underneath the working lock was a 6-inch iron pipe for blowing off the tunnel, provided with a valve on the atmosphere end, and above the lock was a pressure regulating pipe with a safety valve on the atmosphere end, by which the tunnel could be ventilated by raising the pressure above that at which the safety valve was set. Compressed air was furnished to the face of the work through a 5-inch pipe, which was carried along as the work progressed, and the end of which was at all times within 50 feet of the working face. Water was carried to the face through a 2-inch pipe and kept close enough to the work to supply the mortar boxes through 25 feet of hose. Electric light wires and telephone wires at all times extended to the face and maintained light and communication. The telephone gave us the most trouble, as the instruments could not stand the atmospheric conditions for any great time without repair, but they were well worth any trouble that they caused us.

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*Read before the Civil Engineers' Club of Cleveland, Slightly abridged.

After the air locks were in position and found to stand the pressure, work was continued excavating and bricking-in without serious delay, and the only stops made were on Sundays and holidays. Each Sunday the tunnel was thoroughly cleaned and ventilated, wires overhauled, telephone adjusted and other necessary work on the plant performed, ready for the night shift to go on at 11 o'clock. There were two shifts of miners, one going on at 11 P. M. and the second at 7 A. M. The bricklayers went on at 3 P. M. and bricked up what had been excavated by the mining shifts. For about 1,000 feet after the air locks were placed, the pressure was 8 to 10 pounds; for the second 1,000 feet it ran from 10 to 20 pounds, and for the rest of the tunnel from 20 to 27 pounds. At one point where bad ground was encountered, the pressure for about 12 feet of working distance was 37 pounds. The tunnel was completed as far as the location of the river shaft, and the sump under same was then built, after which the remaining 75 feet of tunnel and the two end bulkheads were constructed. This work was completed on the fourth day of April, 1905, and work was commenced on the river shaft at the crib. The entire time occupied in constructing the tunnel was nine and a half months from the first laying of brick, or an average of about 335 feet per month; but from June 14 to August 1, 1904, we only built 200 feet, being delayed by putting in the air locks and scarcity of brick, the latter coming very slowly at first. In the month of January, 1905, we built 454 feet 4 inches, during which we reached our maximum of one day's work, namely, 21 feet 2 inches, on January 23; 20 feet 3 inches, on January 16; and an even 20 feet on January 9. Our average during the month of January was 17 feet 6 inches per day.

The mining shifts consisted of one foreman, four miners and six muckers in each shift, also two drivers and one lock tender. The first mining shift excavated the top half of the tunnel to such distance from the end of the brickwork as the foreman considered could be bricked up in eight hours, and then took out as much of the bottom as they could in the remainder of their shift. Before commencing their excavation they had to strike the centers and put in the floor and track through the section of tunnel completed by the last shift of bricklayers.

The second mining shift completed the bottom and trimmed the circle and set in place the form for the invert. The reason that it requires more time to do the second half is on account of the men having to lift a large part of the material from three to five feet to place in the cars.

The bricklaying shift consisted of four bricklayers, six to eight helpers, two drivers and one lock tender. The number of brick to the foot being about 825; our average for the month of January of 17½ feet meant the laying of about 14,440 brick in eight hours, or 3,610 brick by each man. This means from 7 to 8 brick per man per minute, and when it is remembered that the keying up of the arch can only be done by one man, and that it ordinarily requires from 45 minutes to one hour to key up, it will be seen that in laying the bottom a much faster rate must be kept up. Besides this the centers have to be set, requiring from 20 to 30 minutes, which again operates as a delay. The maximum day's work of 21 feet 2 inches was laid up by the bricklayers in nine hours, and required 17,464 brick, or an average per man of 4,366.

The men outside the air lock were divided into two shifts of twelve hours. The day shift consisted of one engineer, one elevator man, one driver, and from two to four laborers. The night shift consisted of one engineer, one fireman, one driver and two laborers. The arrangement was as above until we found it necessary to make three shifts on top, leaving only the engineer, fireman and elevator man on twelve-hour shifts.

Mules were used for hauling the excavated material out of the tunnel to the air lock, from which it was taken on the elevator to the surface and again hauled by mules out on the dump. The month in which we made the best record was full of snow and sleet storms which impeded us in handling the material on the dump, and also in delivering materials into the tunnel. The latter work was done in the same manner as the removing of the earth, namely, by means of mules. The cars used in hauling earth were so made that the sides and ends being removed they were suitable for hauling brick. Also there were boxes provided in which the cement and sand were mixed dry and thus sent into the tunnel on the cars, the mortar being wet and mixed in boxes at the face of the work. The mules changed shifts with the men, and went in and came out after a few trials as easily as any one. After one mule was killed by falling down the shaft, bars were put up to prevent such accidents, and the mules rode up and down like old miners. One mule only was obstinate as to going into the tunnel, and when he was once induced to go in, the air seemed to intoxicate him, and he ran down the tunnel and drove the men to the furthest limits, winning in the first round. This, together with his power of striking a blow with his feet, caused him to be christened "Terry McGovern," and he was used on top in future to haul out on the dump. The lintels over the shaft-house doors showed many marks of his hoofs, and his drivers were kept busy dodging him.

The only accidents that occurred in connection with the tunnel were two in number, one being when a driver fell and had his leg broken under a car, and the other when a laborer on top had two fingers crushed under the side of a car. Several men were affected by the bends, but none very seriously. The company provided facilities for hot baths for the men at the power house, also for coffee without limit. Medical attendance and examination of the air were also provided for. Every man who worked in compressed air had to be examined before he was employed to see that he was in a suitable physical condition to work in the tunnel.

Preliminary work on the river shaft was commenced on March 16, 1905, by taking tools and materials out to the crib, erecting derricks and setting up engines and boilers. The shaft was designed to be built inside of a steel cylinder having a diameter of 14 feet at the bottom, with a cutting edge extending 3 feet below the curb which held the brickwork. This cylinder was to be sunk to the bottom of the river through an opening in the crib, and then to be sunk through about 26 feet of earth to the top of the tunnel. Guide timbers were placed so as to keep this cylinder in a vertical position, the cylinder was then placed on a raft inside the crib and a watertight floor put in under the curb.

The raft was so constructed that it could be removed when the shaft had nearly reached the bottom of the crib by releasing the lines on one end and pulling the timbers out at the other. To prevent accidents, the lines holding the raft were attached to the heavy cross timbers of the crib at the top so as to support the shaft in case it leaked enough of water to overcome its buoyancy. Also a pulsometer was placed inside and hung from the derrick, steam for same being furnished through a pipe from the auxiliary boiler with hose connection. The steel shaft was made in sections and riveted together on the crib as the cylinder was sunk. The brickwork was started on the curb and was successfully built up for a height of about 16 feet, when the shaft was found to be so close to the bottom that the raft had to be removed in order to permit the shaft to enter the opening left for it in the bottom of the crib. With misplaced confidence in the pulsometer and the night watchmen, the shaft was left over night; the pulsometer acted badly, the watchmen thought they knew how to correct it, did not blow the whistle for assistance as they should, and neglected to use the buckets to bail out the shaft, which would have saved it, and the shaft filled with water and sank about 4 feet into the bottom of the river. It was in its proper location, however, and work was at once commenced to lower the water around it so that the steel cylinder could be extended by riveting on the top section. Several attempts to do this were unsuccessful, and finally the ports through which water entered the crib were blanketed and the inner chamber of the crib was pumped down low enough to permit the riveting to be done, after which it was easy to pump out the shaft. The watertight floor was then removed and the brickwork continued to the top of the lower cylinder. As the brickwork was built up, the shaft kept sinking into the clay, which was carefully excavated so as to keep the shaft plumb, and there was so little resistance by friction that without any external loading the shaft sank to the top of the tunnel, landing almost exactly in its proper location. The above described accident delayed the work about 30 days. The shaft was completed, including the underpinning, on June 19.

Meanwhile, from April 5 to May 11 and from June 14 to July 1, men were at work scraping and washing the tunnel, finishing by cleaning the shaft. The air locks were removed, buildings and plant were shipped away, the surface of the dump was graded and other necessary work was done. The actual completion and acceptance of the tunnel and river shaft covered by the contract were made 95 days before the date set in the contract.

A short time before the tunnel was completed a pipe was driven at the edge of the crib on the engineer's center line to a depth such that it would show in the tunnel when we reached that distance, and it was duly encountered about one foot to the left of the center of the work. From this point we deflected the tunnel so as to bring the shaft connection in its proper location under the center of the crib.

In the month of December, 1904, we had our only difficulty in the work, having encountered a sand pocket on the night of the 16th. This was the only place in the tunnel where the roof required timbering, and was the cause of the increase of pressure to 37 pounds for three days, after which we returned to the normal pressure.

Previous to the letting of the contract, the engineers had taken borings for the entire length of the work, and our findings corresponded exactly with their reports, the material being a stiff blue clay through the entire length of the tunnel, except the sand pocket previously mentioned. This material was of such a character that semi-circular knives were used to cut it out.

ACETYLENE LIGHTING AND STORAGE*

Much has been written concerning the dangers of the use of acetylene, owing to the fact that it possesses the power of combining with metals, such as unalloyed copper, to form an explosive compound known as acetylide of copper, and to the fact that it will, under a pressure exceeding two atmospheres (gauge), separate into its component parts, carbon and hydrogen, such separation being attended by a great increase in volume, and, therefore, an explosion.

These statements are in the main true, but the common acceptance of them exaggerates their importance. For instance, it is stated that free acetylene under a pressure exceeding two atmospheres may be detonated by a slight shock or jar. The practice on one Canadian road with free acetylene stored in cylinders under a pressure of ten atmospheres has been attended with numerous explosions and quite a number of deaths. In each of these instances, however, we are unable to determine just how severe was the shock the cylinder received which caused the explosion. The uncertainty has led to the exclusion, by the Canadian Government, of any acetylene system using free compressed acetylene gas.

Assuming that the gas stored in such receivers were chemically pure acetylene, C_2H_2, there would still be another danger to be avoided. Should any part of these cylinders, owing to a wreck taking fire, be heated to 1,200° F., it would produce the ignition of the entire volume of gas within the cylinder, and the consequent explosion of the latter. Should ignition occur within the receiver containing free acetylene gas, this ignition is communicated immediately to the entire volume of gas, thereby causing an explosion of the most violent order. This ignition cannot be communicated through very fine apertures, such as burner orifices, or finely divided substances, such as asbestos, Kieselguhr, infusorial earth, or unglazed brick. These substances possess a porosity of 80 per cent., and the interstices are of such minute calibre that the transmission of flame through them is impossible. Researches have led to the use of acetone, a combustible organic liquid of high solvent power, which boils at 133° F., and at 60° possesses the power of absorbing twenty-five times its own volume of acetylene gas per atmosphere. Free acetylene gas possesses the largest known range of explosibility, or forms an explosive mixture with both the minimum and maximum admixture of air. When stored in acetone the gas carries with it a fractional percentage of acetone vapor. This vapor reduces the upper explosive limit about 16 per cent. Owing to the high price of asbestos, a mixture of infusorial earth, charcoal, oxide of zinc, and chloride of zinc is employed in France and Englind as a porous filling. This material forms a paste which, upon being dried, resembles chalk, which possesses a porosity, or cellular air space, of 80 per cent. In the United States the cylinders are packed with asbestos discs, the structure of which is obtained by building up the discs and cementing them together with silicate of soda. These discs have the same porosity as the French mixture, but possess the immense advantage over the latter of never breaking under shock or vibration.

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*Abstract of a paper by R. E. Bruckner in *Stevens Institute Indicator.*

We thus have acetylene gas held in suspension or solution in the liquid acetone, this liquid being itself absorbed by the asbestos packing, and thoroughly saturating the latter. In so doing, the acetone itself is in very finely divided particles and offers the maximum absorption surface to the gas. The propagation of a flame or a shock through the entire mass is a physical impossibility. Experiments have shown that an electric spark may be passed through a charged cylinder and it will only produce local ignition.

The ordinary receiver used on railroads for Pintsch gas, and measuring 20 by 114 inches, contains, at a pressure of ten atmospheres, approximately 200 cubic feet of gas. A cylinder of the same size packed with asbestos and charged to about 40 per cent. of its volume with acetone, is capable of containing, at ten atmospheres, 2,000 cubic feet of acetylene gas. A lamp burning one and one-half cubic feet of acetylene gas is capable of delivering 2.3 times as much candle-power as a standard railroad lamp using any other illuminant and consuming from three and three-quarters to five cubic feet of gas, which makes it possible to store in one car at one charge sufficient gas to light the car two and a half months.

A charging plant is erected near the terminal or main railroad yard to be equipped. This consists of a generating apparatus, gasometer, or storage receiver for low-pressure gas, dryers and purifiers through which the low-pressure gas is passed to the compressor, which compresses the gas to ten atmospheres, into a storage receiver consisting of a series of cylinders filled as described before, wherein from 10,000 to 20,000 cubic feet of gas may be maintained. The generation is accomplished by means of a carbide to water generator. The gas produced from carbide manufactured in this country shows 98.67 per cent. pure acetylene gas, and as only traces of oxygen, sulphuretted hydrogen, and phosphoretted hydrogen are obtained, very little purification is necessary.

The compression is accomplished by means of a three-stage, water-jacketed compressor. Intermediate receivers, water-cooled, are provided between the stages. The distribution of the gas is accomplished by means of pipe lines leading to the various tracks and fitted with suitable connections.

Acetylene is known as a 50-candle-power gas, which means that when acetylene is burned in the most advantageous burner at the most advantageous rate, it will give approximately 50 candle-power per cubic foot per hour. The twin burner, in which two jets of acetylene are caused to impinge at an angle of 45° against each other, thereby flattening out into a flame at right angles to the plane of the jets is used. Each tip is so constructed that air is admitted in an annular ring around the issuing jet of gas, thereby preventing contact of the gas with the wall of the burner. These burners have proven perfectly successful and have been produced by various firms. Unfortunately they do not realize the high candle-power obtainable from a fish-tail burner. Their values may be summarized as follows:

Gas Consumption Per Hour	Actual Candle-Power	Candle-Power Per Cubic Foot
¼ cubic foot	6.12	20.36
½ cubic foot	16.01	32.68
¾ cubic foot	27.74	36.36
1 cubic foot	37.28	41.09

From the above it will be seen that the efficiency diminishes as the gas consumption is decreased, or the smaller sizes do not give a proportionate candle-power. Assuming the actual average candle-power of a 1-foot burner to be 40 candle-power, the relative efficiency of the various sizes would be as follows:

Consumption Per Hour	Relative Efficiency
1 cubic foot	100.0
¾ cubic foot	92.4
½ cubic foot	80.0
¼ cubic foot	61.2

In actual service conditions, two ¾-foot burners will give a higher candle-power than three ½-foot burners with the same consumption of gas.

The development of this art has been held back to a very great extent by the prohibitive price of carbide from which the gas is made. This product is controlled in the United States by a single company. Its cost of production is about $20 per ton and its selling prices ranges from $50, the price at which this company sells in Europe, to $90 to $100, the price at which it sells on the Pacific Coast. However, as the time limit of the patents is nearly run out, the possibility of a far cheaper illumination by means of acetylene gas may be anticipated in the near future.

COAL MINE VACUUM CLEANING

The diffusion of coal dust in the air has been a frequent cause of serious fires and explosions in English coal mines, and various devices have been employed to get rid of it. It having been proposed in the progress of parliamentary investigations to use the vacuum cleaning principle for the purpose, a special apparatus has been devised and successfully applied for this purpose. The device here shown is used in the Whitwood collieries, Normantown, England.

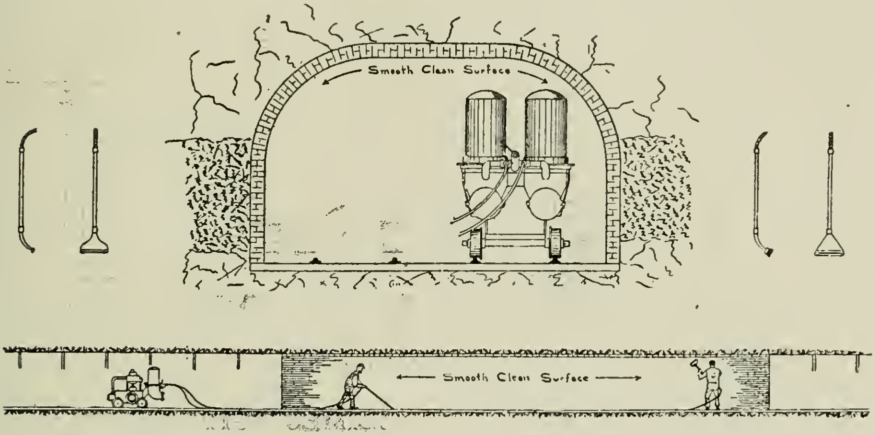

Fig. 1. Vacuum Cleaning in a Coal Mine.

In this case the main roadways of the mine are prepared with concrete sides and roofs, whitewashed by a compressed air apparatus and kept free from dust by periodically going over it with the vacuum cleaner. It is claimed that watering is not only ineffective in cleaning away the fine coal dust which is the source of danger, but that after the water has dried up, which is inevitable in a warm mine, the dust is more friable than ever. The cost of operating the vacuum cleaner is said to be less than that of watering the sides and roof, and it is at the same time more efficient.

An explosion which occurred at Blackwell collieries commenced at a point in the interior of the mine on the main roadway in the intake air course, having been initiated by a shot which was bored to blow out an obstruction on the side of the roadway, but the force of which was liberated by a crack or joint of the strata, and only partly did its work. The dust was stirred up and ignited, and the blast extended along the roadways so far as the fine dust extended, but on reaching the inset, the walls of which had been cleaned and whitewashed, the explosion turned off at an angle, and followed along another main intake airway where there was dust, stopping when the fine dust was absent. The contention is that the light dust adhering to the tops, bottoms and sides of the timbers and supports of the mine, roof and all cracks and interstices, which can be approached within two inches, or where a yardstick can be inserted, can be sucked clean of inflammable dust, which may be removed from the mine and conveyed to the coke ovens or briquette plant.

The apparatus, driven by compressed air, will run on any ordinary roadway in the mine, and will pass wherever a pit tub will travel. Four or five nozzles, connected with flexible hose to the filters of the cleaner, will permit of four or five men simultaneously collecting the dust. The filters being in duplicate, one may be cleaned and emptied while the other is in action.

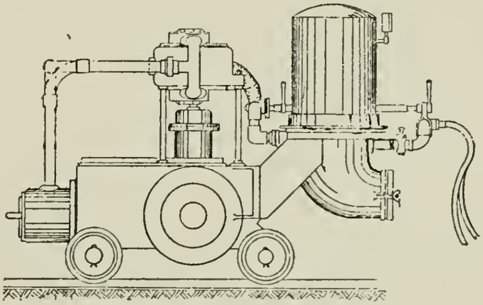

Fig. 2. The Apparatus.

Fig. 1 gives longitudinal and cross sections of the same roadway with the plant at work, showing two operators cleaning smooth prepared zones. The plant is equally suited for removing the dust from timbering, walls, etc., of the unprepared roadways. The plant, which is mounted on a carriage which travels on the mine tramway, consists of a power-driven suction pump, connected to two filter collectors, from which lead flexible hose pipes. At the ends of these flexible pipes are attached suitable cleaning implements with which the operators remove the dust. The cleaning implements may be of various shapes and fitted with or without brushes, as shown in Fig. 1. The great rush of air into the cleaning implement, due to the high suction of the pump, causes every particle of dust over which the implement is passed to immediately enter it, and thence travel through the flexible hose to the filter collector, where it is retained. When one collector is full, the other is immediately put into operation by moving a lever, and the first is then emptied into a skip or bucket for removal from the mine. One operator can free from every particle of dust about 250 square yards of prepared zone surface per hour with reasonable diligence. The plant may be driven either by compressed air from the mine main or by spark-proof electric motor.

Fig. 2 shows the compressed-air driven plant as supplied to the Whitwood colliery, capable of employing six men. The power necessary to drive the machine is from 5-horsepower to 6-horsepower. The plant travels on the mine tramway, taking its power from points in the compressed-air main, and its over-all dimensions are 4 feet 4 inches high, 6 feet 3 inches long, and 3 feet 3 inches wide. Fig. 3 shows the compressed-air driven plant as supplied to the Courrières mine, France, of the same capacity as that illustrated in Fig. 2. The filter collectors are in this case mounted upon a separate trolley, and another trolley is provided for carrying a drum of compressed air supply pipe, so as to give greater range of action to the plant without the necessity of using extra lengths of hose for the operators. The above description is abstracted and the cuts are taken from *The Iron and Coal Trades Review*, London.

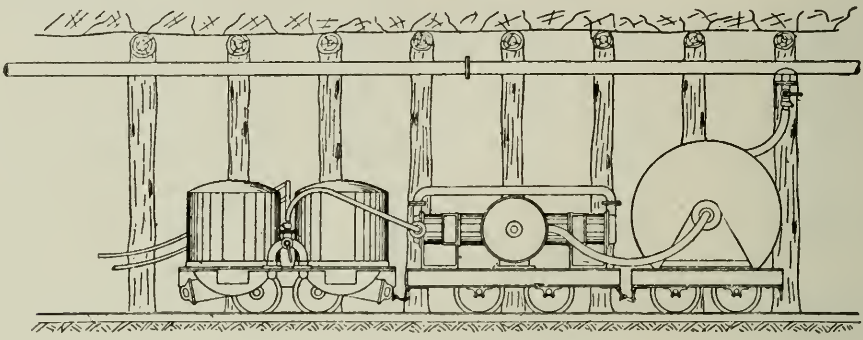

FIG. 3. APPARATUS USED IN FRANCE.

SLIMES AGITATION BY COMPRESSED AIR*

The use of compressed air for the agitation of slimes to assist in the solution of gold and silver in the cyanide process is widespread and its advantages are many and well known. Its economical application is, however, of utmost importance, and, as a result, many mechanical devices have been originated.

The Solis agitator is the invention of Mr. Benito Solis, metallurgist with the Negociacion Mineria Guadalupe de los Reyes, at which company's works in Northern Sinaloa, Mexico, it was perfected and where twelve have been in satisfactory use for over a year.

The metallurgical practice at the works is stamp-crushing, followed by pan-amalgamation of battery pulp and regrinding of tailings in tube mill with sands treated by percolation and slimes by agitation. The ore averages about $25 to the ton, with values about equally divided between gold and silver. About 70 per cent. of the values is recovered in the amalgamating pans. The slimes are reground to 200-mesh in a Krupp tube-mill of 4 feet diameter and 19 feet length.

Blow tubes, worked by Mexican men and boys, were formerly used in the agitation of the slimes, and the labor expense was a considerable item. With the use of the Solis agitator, a saving on labor costs of over $450 per year per tank has been effected, in addition to a saving in time of 24 hours—the slimes (75 tons of pulp and about 75 tons of solution) now being agitated but 72 hours instead of 96 hours as formerly.

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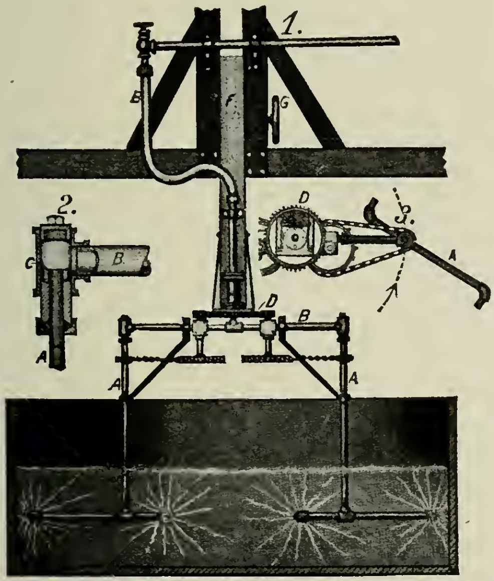
*Geo. G. Lyle in Mining Reporter. Slightly abridged.



Solis Slimes Agitator.

The accompanying engraving shows the Solis agitator in operation. It runs by the impulse of the compressed air issuing from the nozzles. Depending into the tank are a pair of pipes A, formed at their lower ends with tubular heads, each head ending in a pair of nozzles as shown in the plan view 3. The pipes A communicate with a transverse pipe B at their upper ends, the form of coupling being shown at 2. The pipe A, it will be observed, projects through a stuffing box and is formed with a collar C at its upper end which has ball bearing with the top of the stuffing box. Thus, the pipes A are permitted to rotate. Each pipe A is connected by chain and sprocket gearing with a pinion journaled on the pipe B and which meshes with a fixed gear D. The pipe B communicates with a flexible pipe E which is connected to the compressed air supply pipe. In operation the air is forced through the system of piping and out of the nozzles strikes the liquid in the tank and by reaction causes the pipes A to rotate. This motion is communicated to the pinions which, by reason of their engagement with the fixed gear D, cause the pipe B to rotate and revolve the pipes A. The pipe B and the fixed gear D are secured to a beam F which is arranged to slide in the main frame of the apparatus. A pinion operated by the hand-wheel G engages a rack on this beam and provides for vertical adjustment of the apparatus so as to move the pipes A to any desired depth in the tank.

The agitator not only renovates the contact surfaces and oxygenates the solution, but agitates in such a manner that it brings every particle of mineral in contact with the air and cyanide solution.

No claim is made that it can be used in the agitation of sands, although it has done good work when the slimes contained as high as 25 per cent. sands, *i. e.,* sands that will not pass 125-mesh.

The arms are made of ordinary gas piping, so that in case of breakage they may be easily replaced. In the ones in use the top horizontal pipe is 1½ inches in size, the uprights depending therefrom ¾ inch, and the immersed arms ½ inch—all sizes commonly found about mills.

About 3 h. p. is required in its operation in a tank of 31 feet diameter and 8 feet depth, when the arms are of a length of about 7 feet; it would, of course, cost no more for their operation in deeper tanks. It runs with as low an air pressure as 10 pounds, but 20 to 25 pounds insure easier running. It requires no attention after once started, so long as the compressed air is supplied.

COMPRESSED AIR IN THE BOILER SHOP

We are glad to reproduce here, somewhat shortened, an editorial from a recent issue of *The Boilermaker.* While there are two or three things in it which we perhaps would have said somewhat differently, it leads decidedly in the right direction. The article is in the way of announcement of a series of papers upon pneumatic tools, what they will do and how they should be operated and cared for:

From the way in which pneumatic tools are handled by the workmen in some boiler shops, it would appear to the casual observer that such appliances are of no more value than an ordinary sledge hammer or drift pin. While no good mechanic would fail to realize that even the smallest and least important pneumatic tool is a delicate and expensive piece of machinery and would use it accordingly, yet when placed in the hands of an unskilled mechanic, the same tool is frequently subjected to various abuses which result in a loss of efficiency if not in the destruction of the tool.

While the economy and usefulness of pneumatic tools have been thoroughly demonstrated and have been, in fact, the cause of their extensive use, there are some points regarding the installation of the air compressor and system of piping which should not be forgotten. Progress in the use of compressed air has been rapid, and it was only about ten years ago that this form of power began to come into general use. At that time a simple air brake pump was frequently used for a compressor. Naturally, the cost and trouble of maintenance of such a crude form of compressor was considerable.

Compressed air systems are now installed in a variety of ways, some users preferring to use one or two very large units for compressing the air and then conveying the power through long, complicated pipe systems to the point where it is to be used. Of course, greater refinement in design can be obtained with the large compressors, and since the loss in transmitting power through long pipe lines amounts to very little if the lines are carefully inspected, and all leaks prevented, this is generally conceded to be the most economical installation. Compressors up to a capacity of 200 cubic feet of air per minute and a pressure of 100 pounds per square inch are usually single-cylinder, double-acting machines. Above a capacity of 200 cubic feet per minute and at higher pressures a two-stage compressor shows better economy. The duplex type with two simple cylinders, except for low air pressures, which do not warrant compounding, have nearly all been superseded by the two-stage type. A two-stage compressor compressing 100 cubic feet of free air per minute from the pressure of the atmosphere to 100 pounds gage pressure, shows a saving of about 35 per cent. over a single-stage compressor. The steam cylinders are generally compounded when the pressure at the throttle is 150 pounds per square inch or over.

An air compressor works with much greater economy when it can be run at moderate speed than when it is forced to high speed or beyond its normal capacity. Therefore, when installing a compressed air plant it is of the utmost importance to provide a large compressor. It is never safe to depend upon intermittent work in different parts of the shop to keep a moderate sized compressor working all the time. Sufficient capacity should be provided to supply the whole shop at the same time and to provide in addition to this a large margin for an increased demand.

After the proper compressor has been installed the economy of the plant may be greatly affected by the intelligent installation of the distributing pipe lines. Above all, the pipes should be of large size, since a large sized pipe gives a good storage capacity and prevents loss of power, due to friction of the air in the pipe. Provision should be made for a drainage of moisture in the pipe, and the arrangement of the pipe should be such that an accident or leak in one section will not tie up the whole plant. Some workmen seem to have the idea that since air is free to breathe it is not necessary to economize in the use of compressed air, but it should be remembered that it takes coal to compress the air, and even a small leak, say from a 1-16-inch hole, may mean the loss of a horsepower or more.

Moisture can be prevented in the pipe system by the effectual cooling of the air after compression. Likewise dirt and grit, which are extremely detrimental to delicate pneumatic tools, can be filtered from the air by the use of suitable screens. The air cylinders in the compressor should be lubricated with an oil which has a high flash point.

PROGRESS IN AERONAUTICS

The following is a portion of an address at the opening of the International Aeronautical Congress in New York by Professor Moore, chief of the Government Weather Bureau:

"Since the last International Aeronautical Congress, that at Milan in 1906, two practical solutions of the problem of aerial navigation have become established. Several dirigible balloons have been produced which are truly and effectively navigable, and a dynamic flying machine has been evolved which has flown many times, the maximum being twenty-four miles at a stretch. Moreover, there have been great advances in meteorology, so that we are now well on the way to the dominion of the air.

"The previous congresses chiefly discussed the means and methods that might be employed to achieve success; they pointed out the conjectured way; and now that success has come in a rudimental way at least, it remains to discuss further the evolution to be accomplished and the possible uses of balloons and flying machines. The paramount fact is that in order to be practically efficient the dirigible balloon should attain an inherent or 'proper' speed superior to that of ordinary winds. Scientific observations in France have shown that at Paris, at a height of say 300 feet above the Seine River, the probabilities of encountering a wind of less speed than thirty-two miles an hour are 798 in 1,000; that the chances of wind of less than twenty-eight miles an hour are 815 in 1,000, so that the possibilities are that a balloon possessing the latter speed could hold its own on 297 occasions or days of the year."

After telling of the work of foreign governments in this line, Mr. Moore said:

"In the United States the government has done practically nothing toward building dirigible balloons. This has been left to private initiative, and the only returns possible thus far are from public exhibitions. Mr. Stevens, Mr. Baldwin and Mr. Knabenshue have built and flown small and slow airships. They could have shown more speed if they had built larger ships, but this was beyond their means, for the Patrie is said to have cost $60,000. On the other hand, Mr. Wellman has built a very large and moderately fast airship in the daring project to reach the North Pole, and it is earnestly hoped that his third attempt next year will be crowned with success.

"It is thus seen that dirigible war balloons have been developed to an inherent speed of twenty-eight to thirty miles per hour. This is not likely to be exceeded very soon, for although the possible speed increases with the size, the danger and difficulties of handling such frail structures increase also. It is probable that the Zeppelin airship, 413 feet long and 38½ feet in diameter, is on the border of impracticability. The present speed may prove satisfactory on comparatively still days, but it remains to be ascertained by practice to what height balloons will have to ascend to be reasonably safe from gun fire and what winds will thus be encountered.

"The balloon possesses, however, two advantages over the flying machine. First, it can lift a greater proportionate surplus weight with increase of size. If this is not utilized for a more powerful motor projectiles may be taken up.

"The second advantage is that in a contest between the two (a flying machine and a balloon) the balloon by discharging ballast can rise vertically much faster than the flying machine, and the upper position confers great advantage both for attack and defense, as evidenced by all the contests between birds. The chief use in war, however, both of the dirigible balloon and of the flying machine will be in scouting and in directing artillery fire by use of wireless telegraphy. They will carry little surplus weight and their offensive operations will be limited, although occasionally lucky shots may prove decisive in their consequences, such as the destruction of a warship or of a powder magazine.

"Now that the air is to be navigated, the study of meteorology becomes more important than ever before.

"It is evident that the first application in aerial navigation will be to the art of war, and it is clear that its main usefulness will be in reconnoissance, for the loads which can be carried will be small. Balloons have not reached nearly their limit of speed and will always be comparatively slow. Flying machines begin with thirty-eight miles an hour and may attain in the future sixty to seventy-five miles an hour, with a radius of action perhaps 200 or 300 miles. Commercially very little is to be expected from either balloons or flying machines. Carrying freight is out of the question, and even profitable smuggling is doubtful. For passenger traffic the number will be so small and the cost so great that no competition is possible with existing modes of transit.

"Moreover, there will always be danger, but even before this has been minimized aerial navigation may serve in sport. This has already occurred with balloons and may be more pronounced with flying machines. The latter will be useful in exploration of otherwise inaccessible places, such as mountain tops, swamps or densely wooded regions. Balloons and flying machines will undoubtedly be used in carrying dispatches and even mail service may be attempted, but deliveries will be irregular. Upon the whole, now that success has come, we see that the conquest of the air has more limited practical uses than was imagined when it was not known how that success was to be achieved, but it may develop new uses of its own and prove an important benefit to mankind."

PLYMPTON CHARACTERISTICS

Dr. Rossiter W. Raymond has contributed to a recent issue of *The Engineering and Mining Journal* an admirable "Tribute of Justice and Friendship" to the memory of the late Professor George Washington Plympton of Greater New York. Dr. Raymond is widely and justly celebrated for his faculty and facility of saying things as no one else could say them, things in themselves eminently worth the saying. His writings always furnish striking extracts when the whole cannot be appropriated, as note the following:

SCHOOL-MADE OR SELF-MADE?

This son's [Plympton's] early education was gained in a public school; but, like so many American boys of that period, he was obliged to leave his school-training incomplete, and give himself to a wage-earning occupation in a machine-shop. The notion still lingers here and there among us, that such enforced practice, interrupting, or altogether cutting off, theoretical instruction, is a good thing in itself. This is like the superstition that the endurance of hardship inures a man to further hardship. But we have found out in the field that white men could surpass in this respect the half-starved, half-frozen Indians of the plains and that in the war of the Rebellion recruits drawn from the comparatively comfortable life of the city could stand more of fatigue and deprivation than those who came from the strenuous training of farm-labor. The truth seems to be that foregoing severities of experience do not strengthen men, but simply, that they sift out the weaker men, so that, on the whole, the strongest only survive—though even these are not as strong as they might otherwise have been. We may say, in like manner, that deficiencies of early education and the necessity of self-help are not in themselves advantageous; but that those who defy and overcome them are likely to be men of strong, resolute character and high ambition. The fact that "self-made" men always try to give to their sons the early advantages which they could not command for themselves, is an additional proof of this proposition. Moreover, it is easy to over-estimate the scope of school-training. To some young men, it is invaluable, and the lack of it can never be made up. Others already endowed with the gift of intelligent study and the art of dealing with men, easily replace, during the years of practice, what they did not learn in school.

SLEIGHT OF HAND [MIND?] IN PEDAGOGY.

In his work as instructor at the Polytechnic, Professor Plympton exhibited in high degree his peculiar ability to stimulate and inspire his pupils. It may fairly be said that in many departments, and especially in those which concern rudimentary knowledge, the future usefulness of which is not immediately obvious to the young student, the teacher's greatest difficulty is to make the necessary initial drudgery interesting to beginners who do not appreciate its value. No pupil of his ever presented that difficulty to him. While he was still carrying his students through the alphabet of science, he began teaching them to spell. A happy instance of his method, accidentally made known to me, is the way in which he was accustomed, in connection with his course in physics, to induct his classes into the mysteries of legerdemain, of which quasi-scientific art he was himself an accomplished practitioner. Those who are acquainted with the history of this art need not be told that such masters as Houdin made use of the latest scientific discoveries in magnetism, electricity, etc., for the working of their seeming miracles, and that the marvels not thus to be accounted for were tricks, performed by skilful hands in the presence of untrained observers. Indeed, when I note how many honest, good, even scientific people, are continually deluded by such "occult" performances, I am almost ready to declare that instruction in legerdemain ought to be a part of every course in physical science. At all events, Professor Plympton made it incidentally a part of his course; and I remember with pleasure the account he once gave me of a couple of his students who, upon their graduation, made a journey to India, and, being amply furnished with money, made it their business to see, at any cost, the best that Indian magicians had to show; and who, after their return, reported to him that they had witnessed absolutely nothing which they were not able, through the previous instruction received from him, to detect at once as a mere trick—and, in most cases, a very clumsy one. Plympton, in telling me of this incident, connected it with the historic encounter between Houdin and the magicians of the East, in which the French expert not only divined and reproduced all their miracles, but performed others which they could not copy or explain.

COULD NOT GET ANGRY.

The great secret of this extraordinary administrative success was undoubtedly the man's invariable mood of courtesy, sympathy and self-control. Anger always clouds the judgment, and complicates the situation. Now, I never saw Professor Plympton angry—not even when, as the head of the Brooklyn Subway Commission, he was scurriously attacked; and I, as his colleague, was righteously angry for him! Nobody at Cooper Union, so far as I can learn (and my experience is corroborated by the testimony of those who saw him every night for some thirty years of his service there), ever saw him angry. And, most wonderful of all, he was equally gentle and equable at home. His son, a man of mature age, says *he* never saw him angry! I emphasize this feature of his character, not by way of preaching or eulogy, but from the standpoint of an engineer, as an illustration, almost uniqe in my observation, of the saving of energy, the avoidance of "waste motion" through intellectual error, and the increased efficiency and durability of work and influence, through the maintenance of an absolutely constant temperature of mind and heart. Those of us who need to be excited before we can "do our best" are not really ever doing our best. The feverish is not the most forcible. The western phrase, "He did his *level* best," has a deep philosophy in it; for it characterizes the man upon whose strength we can always place our reliance—the man who is always "in good form" for his task, and ready to discharge it with elastic readiness and complete command of its requirements.

SHUNTING THE CRANKS.

I must mention here, as an additional item in the already astonishing catalogue of his numerous occupations, one of his many functions as director of the Cooper Union—a function officially unrequired and unrecorded, and voluntarily assumed. Namely, he used to receive, hear and advise all sorts of inventors and "cranks," presenting more or less revolutionary novelties in scientific theory or practice. Such folks not only drifted to him; they were also referred to him by those who wished to get rid of them. Discoverers of devices for perpetual motion, squarers of the circle, etc., etc., as well as the inventors of devices less clearly, though not less really, absurd, inflicted themselves upon him. From the stories of such experiences which he told me from time to time, I infer that perhaps nobody ever surpassed him in the patient courtesy and secret amusement with which he received and enlightened such crude enthusiasts. The only precedent known to me is that of the Oxford mathematician, Professor De Morgan, whose contributions to "Notes and Queries" (published after his death in that delicious, and now scarce, book, "A Budget of Paradoxes") show what delight he felt in dealing with the queer propounders of eccentric doctrines. The difference is, that Plympton never published the crude notions of his visitors, together with his own witty refutations of them, but simply tried, as a friend, to correct their errors, and guide them to more thorough study of principles.

A DAY'S WORK.

I can remember a time when he used to leave home at 7.30 A. M.; go by horse-car to his duty at the Brooklyn Polytechnic; thence to the Long Island College; thence to his editorial work at Van Nostrand's, and finally to his night's service at the Cooper Union, after which he reached home between 10 and 11 P. M., to repeat the same program on the following day. On Saturday night, however, he permitted himself to break through this rigid routine; and in the memorable, happy days when the *Century* still had its home in 15th street, he and I used to enjoy, that night, an hour of relaxation, before returning together to Brooklyn. As a general rule, he could be found, during this hour, playing billiards—a sign, as I have always thought, of the need, to a mind long strained, of radical and restful change. Yet, on the journey home, much longer in those days than now, he was as freshly appreciative and suggestive as if nothing had happened during the week to make him tired.

Apart from his native gifts, the chief factor of his enduring, versatile intellectual vigor was, as I have indicated, his genial temperament. But, on the physical side, his sound health and regular, temperate habits must be taken into account. One of the habits which played no small part in the maintenance of his powers was that of spending the summer vacation in complete rest and out-door recreation.

AIR PIPE LINE CAPACITIES

South African Mines, printed at Johannesburg, South Africa, is working faithfully for the quickening and betterment of compressed air practice "on the Rand." The pressures employed are not high at the compressors, and at the drills much too low, the result apparently of using pipes of insufficient capacity. The article here reprinted from a recent issue should do good if such things are heeded in that field.

The continual reference by *South African Mines* to the low air pressures prevailing on the Rand appears to be having an effect, as our leading mining and mechanical engineers are beginning to recognize that an underground pressure of 35 to 55 pounds does exist, even though engine-room air charts record 70 to 80 pounds at the surface. The engineering staffs in the town offices, as well as the managers and engineers on the mines, are not only willing to admit the criticisms are justified, but one after another they are making attempts to remedy the evil and save the Rand the £100,000 annually wasted because the underground air pipe lines used are too small for the service required of them.

The greatest power loss on the average mine is unquestionably due to underground air lines being too small, and because so little is really known on the Rand regarding the best size air lines for a certain work, it may not be amiss to give the latest information on the subject. The following tables giving the carrying capacities of various size pipes for various distances are based on D'Arcy's formulæ, and have been proved correct in practice. Decimal points and fractions have been omitted wherever possible, and it has further appeared desirable to suffer a total loss in pressure of about 12 pounds, 3 pounds being accounted for in the air line going down the shaft, 3 pounds in the air lines along the drives and cross-cuts, and 3 pounds in the stopes, with a further loss of about 3 pounds due to bent pipes, short turns, valves, tees, elbows, crosses, etc. Delivering air at the engine-room receiver at 75 pounds, which is the practice here to-day, will then mean getting 63 pounds at the working faces, as against the present 35 to 55 pounds. The best practice does not admit of a total loss greater than 5 pounds, but as 20 to 30 pounds is the present loss in pressure, and wonders can not be worked overnight, let us split the difference and suffer the 12 pounds loss until such times as we realize that this nominal loss is insufferable.

SHAFT AIR LINES.

Assuming the initial air pressure in the engine-room is 75 pounds to the square inch, and that the loss in pressure due to pipe friction is not greater than 3 pounds, we find that a given size pipe line has the following capacity for various lengths:

6-inch pipe line,				
1,000 ft.	long is large enough	for only	19	large drills
2,000 ft.	“	“	14	“
3,000 ft.	“	“	12	“
4,000 ft.	“	“	10	“
7-inch pipe line,				
1,000 ft.	long is large enough	for only	28	large drills
2,000 ft.	“	“	22	“
3,000 ft.	“	“	18	“
4,000 ft.	“	“	16	“
8-inch pipe line,				
1,000 ft.	long is large enough	for only	39	large drills
2,000 ft.	“	“	31	“
3,000 ft.	“	“	25	“
4,000 ft.	“	“	22	“
9-inch pipe line,				
1,000 ft.	long is large enough	for only	54	large drills
2,000 ft.	“	“	41	“
3,000 ft.	“	“	34	“
4,000 ft.	“	“	29	“
10-inch pipe line,				
1,000 ft.	long is large enough	for only	68	large drills
2,000 ft.	“	“	54	“
3,000 ft.	“	“	45	“
4,000 ft.	“	“	38	“
12-inch pipe line,				
1,000 ft.	long is large enough	for only	107	large drills
2,000 ft.	“	“	85	“
3,000 ft.	“	“	71	“
4,000 ft.	“	“	61	“

DRIVE AIR LINES.

Assuming the air pressure at the station underground is 70 pounds, and that a loss of 3 pounds pressure in the drives is not to be exceeded, we have the following capacities for various size pipes for various lengths:

2½-inch pipe line,				
500 ft.	long is large enough	for only	3	large drills
1,000 ft.	“	“	2	“
1,500 ft.	“	“	1⅔	“
2,000 ft.	“	“	1½	“
3-inch pipe line,				
500 ft.	long is large enough	for only	4½	large drills
1,000 ft.	“	“	3⅓	“
1,500 ft.	“	“	2½	“
2,000 ft.	“	“	2⅛	“
4-inch pipe line,				
500 ft.	long is large enough	for only	10	large drills
1,000 ft.	“	“	7	“
1,500 ft.	“	“	6	“
2,000 ft.	“	“	5	“
5-inch pipe line,				
500 ft.	long is large enough	for only	18	large drills
1,000 ft.	“	“	13	“
1,500 ft.	“	“	10	“
2,000 ft.	“	“	9	“

STOPE AIR LINES.

Assuming the air pressure is 65 pounds in the drive and that a further loss of 3 pounds pressure in the stopes is not to be exceeded, we have the following capacities for the various size pipes and for lengths up to 300 feet:

1½-inch pipe line,				
100 ft.	long is large enough	for only	1½	large drills
200 ft.	“	“	1	“
300 ft.	“	“	1	“
2-inch pipe line,				
100 ft.	long is large enough	for only	3½	large drills
200 ft.	“	“	2½	“
300 ft.	“	“	2	“
2½-inch pipe line,				
100 ft.	long is large enough	for only	6	large drills
200 ft.	“	“	4½	“
300 ft.	“	“	3½	“
3-inch pipe line,				
100 ft.	long is large enough	for only	10	large drills
200 ft.	“	“	7	“
300 ft.	“	“	6	“

With the usual engine-room air pressure of 75 pounds, and adhering strictly to the dimensions and capacities given, there will be no excuse for an air pressure at the working faces of less than 60 to 65 pounds—there will be no excuse for the miner not getting in four 6-foot holes before 12 o'clock, and there will be no excuse for the underground official who does not insist on at least two more holes being drilled before blasting time. Furthermore, the air compressor will work a shorter time, because, instead of compressing air for five to six hours to drill four holes per rock-drill, it will only have to work 75 per cent. of this time for the same tonnage broken.

To show what a deviation from the figures in the foregoing tables means, the following remarks are appended:

Increasing Length of Pipe Line by Two, i. e., doubling any length given in the tables and operating off it the same number of drills, doubles the friction loss and makes it 6 pounds instead of 3 pounds.

Doubling the Number of Drills that a given size and length of pipe line is rated for in the tables, quadruples the friction loss and makes it 12 pounds instead of only 3 pounds.

Lengthening a Given Pipe Line or Increasing the Number of Drills over the figures given in the tables, increases the initial friction loss of 12 pounds to 15 pounds in one case, and 21 pounds in the other. This is to be avoided.

HOW COMPRESSED AIR MAY DESTROY SEA WALLS

Mr. O. Fraser, superintendent and ex-government inspector of works, writes to *Engineering News* from Port Colborne, Canada, an interesting letter having to do with concrete sea walls and the conditions under which they are disintegrated by wave action. He says that when the 1-2-3 mixture is used there is no trouble. In one large foundation the crushed stone was abandoned and river gravel was used, 1½ of gravel to 3 of coarse sand. The results were incomparable piers and quays with a face as if it were polished glass.

He says further:

Let those who are building sea and quay walls avoid crushed stone as they would avoid the mischief, and adopt gravel concrete to the proportions given; that is, up to low water or neap tide levels; then adopt 1-2-3. To reduce the cost from low-water level up to coping, use the crushed stone there with 35 per cent. of one-man stone rubble displacers. Then you have a conglomerate, a solid mass of monolithic concrete. Let the rubble displacers be kept back from the face of the form one foot and that solid foot of concrete be well rammed and faced up with a trowel.

I have found that in building these quays and sea walls there was no disintegration, simply for the reason that the face was smooth as glass and as solid as concrete can be made. On building with 1-2-4, which seems to be generally adopted under water, I distinctly say it is utterly impossible to build with these proportions and at the same time use crushed stone. When building, the wall will be in the condition as described, full of holes under water that cannot be pointed, and the portion above water is always damp and will not hold the pointing. And by some it is called disintegration through chemical action; by others it is thought to be caused by ice abrasion, and they are nearer the mark. What can be expected when great blocks of ice come smash on to a face of 1-2-4 concrete? It is not conceivable that two parts of sand will fill the voids of four parts of crushed stone.

The half of the whole mass is full of air. A storm coming on from any direction of the seas is always worse between high and low water, as generally at high water the storm abates. The storm being at its worst at the top portion of the underwater concrete and the bottom portion of the top concrete, it is there where the destruction begins. The top portion may be anything from 12 feet to 20 feet, according to location. Just take that body of water 12 to 20 feet, backed up by the full weight and force of the ocean, coming on with a rush just like a demon, and again receding back 100 feet and coming on with crested waves from 20 to 30 to 50 feet in height, with that snarled crested curve coming on and dashing on to the wall surface that has holes and contains in its body a full half of air. This air is locked in and becomes compressed. That something has to go is certain. Explosions and a series of explosions take place. This goes on from day to day, week to week, month to month and maybe from year to year until it is discovered that the wall is getting cut up, and then it is called disintegration when it should be called air abrasion or compressed air explosions.

The remedy is as follows: For walls under water to any depth, use gravel concrete; use sea water; let the proportions be 4½ cubic feet to one bag of cement; bring up your underwater concrete 2 feet above low water level. Mark this particularly, as the density of your concrete depends on it. Use the full volume of water to one bag; if in dry, hot weather, 4 to 4½ ordinary pails of water, if damp, 3 to 3½. Do not be afraid to give the full volume of water, because when full it cannot receive any more if your concrete has not the full volume; then when you deposit it water is just like air. There can be no voids. It will rush in to fill that void and in its course rushing in it washes away the cement (which becomes free lime). Concrete is just like the hungry man. Give him a full meal, give him a good skinful, and he cannot take any more. This volume of water is for density, solidity, and to produce a face such as no man by any manner or manipulation can produce. With no lodgment for air, your wall will stand for many generations and we will hear no more about disintegration.

GASES OF THE COAL MINES

At a recent meeting of the Midland Branch of the National Association of Colliery Engineers, held at Nottingham, Eng., Professor F. Clowes discoursed upon the above topic. We present a brief abstract:

While chemists use the word gas, miners generally call the gases of the mines "damp" —choke-damp, fire-damp and after-damp. As the gases can be liquefied, they are really vapors, and "damp" is all right for them. The compressibility of the gases has an important bearing upon the damps of the mine. When the barometer is low, indicating a low pressure of the air, miners must be on their guard against the gases, which are then apt to be released. Certain liquids have a slow process of mingling with each other, but all gases mix spontaneously and rapidly. The light, inflammable gases which escape in the roof of the workings have a tendency to mix with the air. The heavier gases on the floor will do the same, and the whole will in time produce a uniform mixture. This mixing is accelerated by the rapid ventilating currents which all collieries have to maintain.

Gases differ in their affinities for and solubility in water. The gases common to a mine are generally only slightly soluble. Water containing caustic soda will absorb carbonic acid gas, and use is made of this in a rescue apparatus for a man to strap on his back. The carbonic acid in the wearer's breath is absorbed by the caustic soda solution and the air is so far purified.

Ventilation is carried on upon such an extensive scale in coal mines that there should be little difference in the air within and without the mine, except for the causes operative in the mine itself. Breathing changes the oxygen of the air to carbonic acid and this to a considerable extent. Fresh air has oxygen, 20.81 per cent.; nitrogen, 79.15; carbonic acid, 0.04, or about that. Breathed or expired air may show oxygen 16.03, instead of 20.81, but the carbonic acid has been increased perhaps a hundredfold by respiration. Every forge below ground also is responsible for an increase of this gas.

It has been found necessary to adopt systems of ventilation, or air renewal, in other places. In the tube railways the air is much more rapidly vitiated and their engineers have taken their lesson from the mines and have adopted similar means for ventilation.

When the oxygen of the air is reduced to 16 per cent., no ordinary flame, as a candle, will burn in it; hydrogen, however, will burn in air which contains only about one-quarter as much oxygen, and coal gas, which consists largely of hydrogen, will burn under similar conditions. "Gob" fires start in the mines from the heating of small refuse which has been neglected. This heating is caused entirely by the oxygen in the air which the coal slowly absorbs, and when the fire is once started it spreads rapidly around.

CHOKE DAMP.

Carbonic acid in the mine escapes directly from the coal and its weight causes it to settle on the floor. It is necessary to search for it in holes in the floor where it is not swept away by the ventilating currents. Carbonic acid is not poisonous. If you try to breathe it unmixed with air your lungs refuse, which gives rise to the name "choke-damp."

CARBONIC OXIDE.

Carbonic oxide, sometimes mistaken for carbonic acid, is extremely poisonous, but it is not produced from the coal. If an explosion of fire-damp takes place with an insufficient quantity of air, carbonic oxide is almost invariably produced, and when explorers go down a small portion absorbed produces fatal results. Unfortunately it is a gas not easily tested for in mines, and the only wise precaution, if there is any suspicion of its presence, is the protection of a breathing apparatus, which is an absolute safeguard in this case. Blast-powder and nitro-cotton produce carbonic oxide, but good active ventilation clears it away quickly.

FIRE DAMP.

Fire damp is not a poisonous gas; one cannot live in it because of the lack of oxygen. In some mines it comes out from the coal as pure marsh gas, but far more generally it is mixed with nitrogen and carbonic acid. This gas is not explosive, and only becomes so when mixed with air in certain proportions. It explodes with the greatest violence when there is 10 per cent. of it in the air, and the range of danger is between 6 per cent. and 16 per cent., beyond either of which explosion does not occur, while fire may. It is always necessary to detect the presence of this gas, because if it increase above the 6 per cent. explosion is possible at once. Lower mixtures also become explosive if coal dust is present in considerable volume. Coal dust, indeed, of a fine character and mixed with air only can carry an explosion to a considerable distance.

The above is abstracted from a report of the address in *The Iron and Coal Trades Review.*

THE AIR LIFT FOR MINE PUMPING

Mr. Joseph H. Hart contributes to a recent issue of the Mining World an interesting article upon "The Pumping Machinery Employed in Mining." After speaking of the wastefulness and other objectionable features of steam pumps as employed in mines and saying a good word for centrifugal pumps under suitable conditions, the writer proceeds as follows:

In addition to the types described above, there are in existence to-day a number of pumps known technically as the air-lift system. That these pumps are not in more general use in mining is a matter of considerable surprise. In ordinary pumping installations where water must be drawn from a number of different sources simultaneously, the efficiency and availability of these pumps is unquestioned. The air-lift system of pumping is based upon the utilization of compressed air for the conveyance of the water. It involves the installation of an air compressor and a reservoir therefor. In the majority of mining operations compressed air is an absolute necessity for the drills, and the presence of an air compressor tends to simplify the problem and will further increase the available efficiency in the whole process. Again, in caisson work compressed air is absolutely necessary under all circumstances. Under conditions where air compressors must be at hand, by increasing the unit slightly the extra unit for operating the air-lift pump is saved. Moreover, with the installation of a single large operating unit, in preference to several small units, the saving benefits the entire plant, and such an operating unit invariably becomes more efficient as the cost per unit is diminished per unit of power capacity of the machine.

Given an air compressor, the operation of the pump itself is extremely simple. It consists merely in sinking a well to a slightly lower depth to obtain the pressure head with which to operate. A pipe is lowered from the pump into this well and compressed air is driven from it through the pipe and rises through the water into another pipe. As it rises in this pipe, the air expands, and by this action and its upward motion the water receives an upward impulse which is sufficient to carry it considerably above its former level. In ordinary practice the height to which water can be elevated by this process seldom exceeds one and one-half times that to which the water falls in the well without reversal occurring. If the pipe which carries the air and water upward is tapped and more compressed air injected, the process becomes continuous, and the water can be lifted to any height. This latter procedure has seldom, if ever, been carried out in mines, and such installations as are in existence are operated so as to make this method for carrying air comparatively inefficient, which limits the application to the distance mentioned.

The air-lift process is much more efficient, however, than the ordinary surface pump. It possesses all the advantages of the ordinary single or multiple turbine pump. The power comes from compressed air in the production of which a fairly high efficiency may be maintained, or at least much greater than that in the operation of ordinary surface pumps. Further, the fact that the air compressor is indispensable under any circumstances practically settles the matter. Turbine pumps generally require a separate steam unit for their operation or for the production of the electrical energy to operate them with, and with the saving of separate units which is involved there is brought into the problem the first cost of installation as well as cost of maintenance.

In action, this system compares very favorably with the centrifugal pump. In ordinary action, especially when the service is severe, enormous friction marks the centrifugal type of pumps. The advantages of the centrifugal pump, incident to the elimination of valves and the possibility of carrying considerable obstructions and detritus with the water throughout its circuit, is present in the air-lift system in its simple form. Many adaptations of the latter type are used for increased efficiency, and in many cases the air is first used in some form of cylinder similar to the ordinary pump for giving the water the upward momentum. The exhaust from this cylinder is then used to further accentuate the upward velocity of the water. The utilization of this type is not possible for the conveyance of water carrying many impurities and solid particles. It has, however, an increased efficiency as compared with an ordinary air-lift system. This efficiency is in the pump proper, and its best operation is dependent upon the power supplied. Both of these factors must be considered separately as well as in their interrelation before an adequate decision can be rendered in regard to any installation.

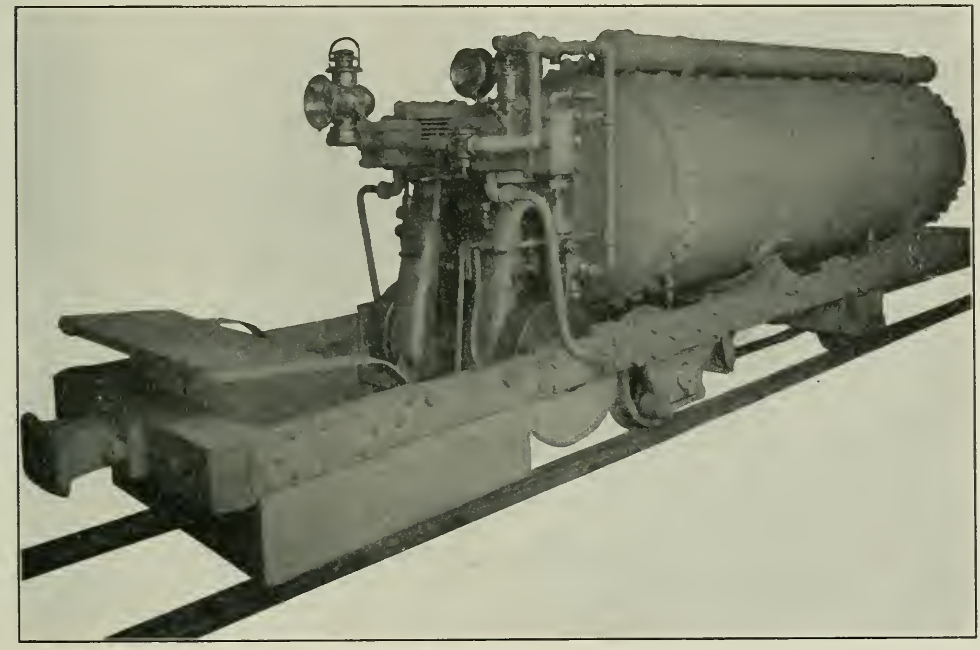
With regard to power production, the fact that compressed air must be used in other developments of mines is almost conclusive evidence for its utilization in this development. Given a supply of compressed air, its utilization for pumping purposes is best accomplished in the simplest and most direct fashion.

POWER FOR THE SHAVINGS EXHAUST FAN

It seems to be a fact that the simple principles of pneumatics involved in the operation of the exhaust fan are not exactly clear in the minds of a great majority of the men who are familiar with the operation of this useful device. It should be clear from the start that the fan can exert force only in one direction, and that one away from itself. We speak of the pull of the fan as though thin air could be drawn or pulled like a rope, while the fact in the case is that it can only be pushed. Suction is not the pulling of the fan or of the plunger in the cylinder, but the forcible shoving away of the air on the other side, in order to create a partial vacuum, into which the air is in turn pushed by the atmospheric pressure outside. It is for this reason that it is impossible to create any great pressure with an exhaust fan, even if it were possible for the fan to produce a perfect and continuing vacuum, as the outside pressure is something less than 15 pounds per square inch, depending upon altitude. Reasoning from these known facts, it will become apparent why an exhaust pipe loaded with shavings consumes more power at the fan than one running empty.

Let us suppose that a fan is running empty, and all at once the pipe is given a normal load of shavings. The result will be that no extra power will be required until the shavings reach the fan, but at that instant the effect will be noticeable in the behavior of the belt, which will show that it is carrying a load instead of running idle. Now let us stuff the inlet to the pipes with an overload of refuse, and we shall see the common symptoms of an overloaded belt; it will squeak and slip, and perhaps slide off the fan pulley and rub over against the castings of the machine, while the fan will slow down, and if the cramming is continued long enough, the pressure will fall below the lifting capacity and the pipes will clog. Need I go further and explain that after the refuse leaves the fan it has to be forced to the outlet of the pipe and discharged in order to make way for that which is following? Must I say that shavings, chips and sawdust are heavier than air, and that it takes more power to drive them along a pipe than it does the empty air?

Just how much more power it takes to carry the load of an exhaust fan depends, of course, upon the load; and the load depends not only upon the number and kinds of machines to be handled, but upon the kind of wood being worked, the length and direction of the outlet and the length and direction of the inlets. No one could say with authority just how much more power it would take to run a loaded fan than an empty one, unless it would be the designer of the fan, and he to prescribe the conditions.—Charles Cloukey in *The Wood Worker.*



A Narrow-Gage Compressed Air Tunnel Locomotive.

A NARROW GAGE COMPRESSED AIR LOCOMOTIVE

The half-tone shows a locomotive designed by Mr. E. A. Rix of San Francisco, who has done much to promote the use of compressed air, especially by novel and original applications of it. Three of these locomotives have been made for a tunnel over three miles long which is being built near San Francisco. The tunnel is being driven from each end and in both directions from a central shaft, thus providing work for the three locomotives. The gage of the locomotive is 20-inch and its weight about 7,000 pounds. It passes through an opening 34 inches wide and 50 inches high. It will haul 12 tons at a speed of 6 or 7 miles an hour, and a charge of air is sufficient for a mile and return. The maximum pressure in the storage tank is 1,000 pounds and a pressure reducer maintains 100 pounds as the working pressure. The engine is, of course, reversible, although the link motion is not used, and there are air brakes and all the necessary fittings for handy and safe operation. A chain drive connects the engine shaft with the axles.

THE POLICY OF SECRECY

The following is an abstract of a portion of a paper by Mr. James Douglas presented at the meeting of the American Institute of Mining Engineers:

Technical science has progressed of late with unwonted speed through the co-operation of many workers, and this co-operation has been made possible by the publication and exchange of ideas and experiences in the technical and scientific journals. Would not our progress be even more rapid and thorough if all barriers of secrecy were broken down, and every encouragement were given to our technical workers to describe, in print and by conference, their notions and their actual experiments?

We know that very few technical papers issue from certain establishments; that on their officials silence is imposed; and that to these works inquisitive visitors are politely but peremptorily refused admission. There are not many such, but some of them are and have been very successful. But suppose that in imitation of their practice and regulations all were tempted to adopt it, what a sudden paralysis of industry would follow! Our secretaries would find it difficult to fill even their shrunken volumes of transactions with papers worth printing; our students would have to content themselves with the antiquated learning which their professors could supply. Every manufacturer and smelter would be obliged to bribe his neighbor's workmen and tempt away his neighbor's superintendents for information. Before long, the very works which now find it so profitable, or who think they do, to tap their friend's stock of knowledge and experience, and give nothing in return, would be driven in upon their own resources, and would undoubtedly then find them not so complete as they imagine.

The spirit of intellectual freedom in our professions is too strong and too widespread to submit to such a tyranny, and before such darkness of ignorance had settled down to our great industries, the most pronounced advocates of secrecy would feel and acknowledge the ultimate consequences of concealment. They may have secrets as valuable as Sir Henry's method of making plate glass and bronze powder, which it may pay them to conceal from their competitors, so long as they are admitted freely to their competitor's open shops; but even this is doubtful. For the spirit of secrecy is intimately allied with the spirit of suspicion and distrust; and the mind which is always suspecting is closed tight against the admission of fresh and fair impressions. Progress, therefore, ceases.

The iron and steel works of Europe have not kept pace with ours in size and production, but the iron-masters of Great Britain and Germany, in coke-making and in blast-furnace economies and in steel-making processes, have been our teachers. Nor have they been shy of communicating their improvements, or, through jealousy of our success, slow in adopting ours. No nobler monument of international comity in thought and experience exists than the seventy volumes of the *Proceedings of the Iron and Steel Institute.* And with few exceptions the iron and steel works of England, Scotland, Germany and France are open to any accredited worker in the same domain.

Yet before England was conspicuous as a maker of iron, she was famous the world over for her copper and tin production. But, between self-conceit and the inbred habits of trade-secrecy, her copper-smelting industry has fallen from its high estate. And it is not accidental, but linked as closely as any effect with its cause, that this decline is in great part the result of habits of secrecy which grew with the growth of age. At Swansea, every gate to the smelting works is guarded, and as a result it has been as difficult for thought to escape out as for suggestions to find their way in. Swansea should still enjoy the leadership which her skilled labor, splendid coal, and commanding maritime situation put within her reach; but she has preferred to gloat over her secrets behind closed doors rather than go out into the world in search of new business as well as technical methods, while also inviting the world to enter and exchange ideas with her. What is the consequence? New Zealand copper comes to the United States to be refined, notwithstanding that the first practical application of electrolysis to metals was made by Elkinton in England, and the Vivians adopted the Manhes method before Farrel introduced it into this country. In scientific and technical matters, the banishment of deceit, mystery and jealousy and the freest admission of daylight by means of the unreserved diffusion of information through the press and personal intercourse, will instil into the whole body of workers a feeling of healthy rivalry, which, while stimulating their mental activity, will correspondingly benefit the financial interests of their employers.

AIR REQUIRED FOR VENTILATION

Under the general conditons of outdoor air, namely 70 degrees temperature and 70 per cent. of complete saturation, an average adult man, when sitting at rest in an audience, makes 16 respirations per minute of 30 cubic inches each, or 480 cubic inches per minute. With 70 degrees temperature and 70 per cent. humidity, the air thus inhaled will consist of about one-fifth oxygen and four-fifths nitrogen, together with about one-seventh of 10 per cent. of aqueous vapor, and four one-hundredths of a per cent. of carbonic acid. By the process of respiration the air will, when exhaled, be found to have lost about one-fifth of its oxygen by the formation of carbonic acid, which will have increased about one hundred fold, thus forming about 4 per cent., while the water vapor will form about 5 per cent. of the volume. In addition, the exhaled air will have warmed from 70 degrees to 90 degrees, and, notwithstanding the increased proportion of carbonic acid—which is about one and one-half times heavier than air—will, owing to the increase of temperature and the levity of the water vapor, be about 3 per cent. lighter than when inhaled. Thus it will be seen that this vitiated air will not fall to the ground, as has often been presumed, but will naturally rise above the level of the breathing line, and the carbonic acid will immediately diffuse itself into the surrounding air. In addition to the carbonic acid exhaled in the process of respiration, a small amount is given off by the skin. Furthermore, one and one-half to two and one-half pounds of water are evaporated daily from the surface of the skin of a person in still life. If the air supply at 70 degrees is assumed to have a humidity of 70 per cent. and to be saturated when it leaves the body at a higher temperature, then at least four cubic feet of air per minute will be required to carry away this vapor.

Taking into consideration these various factors, it becomes evident that at least four and one-half cubic feet of fresh air will be required per minute for respiration, and for the absorption of moisture and dilution of carbonic acid gas from the skin. This, however, is only on the assumption that any given quantity of fresh air, having fulfilled its office, is immediately removed without contamination of the surrounding atmosphere; but this condition is impossible, for the spent air from the lungs, containing about 400 parts of carbonic acid gas in 10,000, is immediately diffused in the atmosphere. The carbonic acid does not fall to the floor as a separate gas, but is intimately mixed with the air, and equally distributed throughout the apartment.

It must, then, be evident that ventilation is in effect but the process of dilution and that when the vitiation to be maintained in the apartments is decided, the necessary constant supply of fresh air to maintain this standard may be very easily determined. For the purpose of calculation, 0.6 cubic feet per hour is accepted as the average production of carbonic acid by an adult at rest, and the proportion of this gas in the external air is as four parts in 10,000. If, therefore, the degree of vitiation of the occupied room be maintained, say at 0.6 parts in 10,000, there will be permissible an increment of only 2 parts in 10,000 above that of the normal carbonic acid in each cubic foot of air. The 0.6 cubic feet of carbonic acid produced per hour by a single individual will, therefore, require for its dilution to this degree 0.6 divided by .0002, equals 3,000 cubic feet of air per hour. Upon this basis the following table has been calculated:

Cu. ft. of Air containing 4 parts of carbonic acid in 10,000 supplied per person.

Per Hour . .	6000	4000	3000	2400	2000	1800	1714	1500	1200	1000	525	375	231
Per Min. . .	100	66.6	50	40	33.3	30	28.6	25	20	16.6	9.1	6.2	3.8
Degree of vitiation of the air in the room. (Parts of carbonic acid in 10,000.):	5	5.5	6	6.5	7	7.33	7.5	8	9	10	15	20	30

The figures indicate absolute relations under the stated conditions, and are generally applicable to the ventilation of schools, churches, halls of audience and the like, where the occupants are reasonably healthy and remain at rest.—*Ventilation and Heating by B. F. Sturtevant Co.*

OXYGEN FOR CUTTING METALS

The cheapness with which oxygen is now procurable and its portability and convenience of handling is leading to its being more and more thought of in the planning of industrial economies and to its actual and profitable employment for many purposes. M. Leon, in *Genie Civil*, describes an important application of oxygen to the cutting of metals as practiced in France.

At the Say refineries a jet of oxygen was employed some six or seven years ago, not for actual cutting, but for breaking down old pipes and I beams. The metal was first heated to the temperature of fusion by a blowpipe and then, discontinuing the application of the heating gas, a stream of pure oxygen was later applied to the heated metal. The operation was in two parts, first the heating of the metal and later burning it away. It was possible in this way to break up the metal into different parts, but the operation produced a very large and heavy cut with many blisters, and it was found impossible to secure a clean separation by this method. It has been successfully applied, however, to breaking down metallic connections in blast furnaces.

The method as at present developed is a great improvement on the old. The apparatus consists of two blowpipes which operate simultaneously; the first, an ordinary oxy-hydrogen or oxy-acetylene blowpipe, heats the metal to the desired temperature; the other, attached to the first and following it at a distance of a few millimeters (an inch or two), projects upon the heated metal which is heated by the first blowpipe, burns under the influence of the oxygen; there is formed an oxide more fusible than the metal itself, which is driven forward by the strength of the oxygen jet. The resulting cut is extremely clean, with no appearance of blistering.

In view of the numerous applications which may be made of the method, a number of different devices have been developed for various kinds of work. Cutting along a straight line, as for steel sheets, armor plate, etc., is accomplished by the use of a traveling carriage, carrying the blowpipe, which is driven by an endless screw. In this apparatus also the blowpipe is mounted on a swinging arm which permits it to trace out arcs of circles. Several of these devices are used for cutting armor plate at the French arsenals and navy yards.

A rolling device, consisting of a blowpipe mounted on a crosshead carrying an adjustable roller at each end, may be used for making either straight or beveled cuts. This apparatus is also provided with a swinging arm for the cutting of circles or spirals. The device is largely used by the Chemin de fer du Nord for cutting T rails.

For cutting pipes, the blowpipe is mounted on an annular ring which is clamped to the pipe and around which the blowpipe revolves. By means of this device pipes up to 300 mm. (12 inches) in diameter may be cut in place. A universal portable apparatus is so arranged as to admit of cutting out any desired section, the blowpipe being guided by cams of special shapes. Other devices may be applied to cutting circular openings of 30 to 350 mm. (1¼ to 14 inches) diameter in plates of any thickness, to cutting shafts up to 130 mm. (5 inches) diameter, and lastly for cutting openings of any radius in steel pipes for the purpose of making elbows, the bevel being cut in the end of the other pipe by the same machine. For the preparation of two pipes of 150 mm. (6 inches) diameter in this way the time taken was four to five minutes, a great improvement on the 30 to 40 minutes required by other methods.

To cut a manhole 300 by 400 mm. (12x16 inches) in a plate 20 to 30 mm. (¾ to 1¼ inches) thick takes from four to five minutes. A pipe fitting, 150 by 150 mm. (6x6 inches), in a pipe 5 mm. (3-16 inch) thick, takes three to four minutes and costs 12 to 15 centimes (2.3 to 2.9 cents), while the same operation could not be performed by hand in less than 35 to 40 minutes.

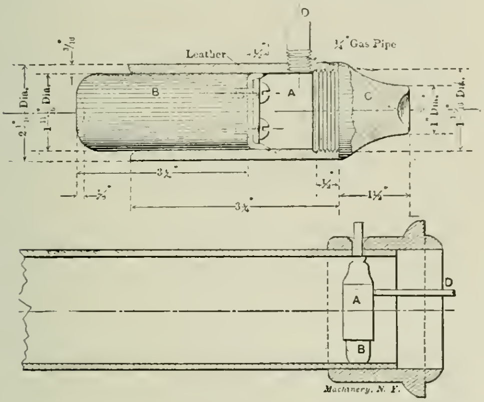
In one case a steel stairway was cut through in a quarter of an hour. A workman cut through 130 T irons, 200 mm. (7¼ inches) high, imbedded in cement, in three hours. The system has been largely used in the French navy yards for the breaking up of ships and has been found very satisfactory in many applications. It is particularly useful in deriveting plates; the head of a rivet can be burned off in less than 12 seconds without injuring the plate itself.

The maximum thickness which has been cut by this method up to the present is 210 mm. (8 inches) in armor plate, but a thickness of 300 mm. (12 inches) has been attained in round shafts. A number of tests have been made to determine whether the cutting by this method has any effect on the physical properties of the metals. Under the microscope the steel appeared quite unchanged, and other tests by shock, etc., showed its strength to be absolutely unimpaired. On this account and considering the cheapness and rapidity of the process, there are prospects for a wide and growing use of the system in the near future.

The Lily-Jellico Coal Company, Lily, Ky., has 600 acres of coal seam 4 feet thick, with 10 feet of earth over it. The earth is to be removed by shovels when all of the coal will be recovered. When operations are under way the excavation will provide its own dumping ground.

A SPECIAL PNEUMATIC DOLLY

The sketch of the pneumatic dolly here shown was sent to *Machinery* by Mr. M. H. Westbrook of Port Huron, Mich. It is used for "holding on" while riveting bolt joint rings on the ends of locomotive dry pipes. The device is not altogether new, but many shops should be glad to adopt it and this full dimensioned sketch will be welcomed. The cylinder *A* has a head *C* screwed into it, this head being reduced in diameter and cupped to fit the head of the rivet. The plunger *B* is pocked with a cup leather as shown, the outer end also being cupped for a rivet head and also rounded so that it may bear between the heads of rivets when that will give the more correct position. Compressed air is admitted or discharged by the pipe *D*. The lower figure shows the dolly in use with a new rivet in position. The air forces the plunger *B* against the wall of the pipe or head of a rivet opposite, holding the rivet tightly in place, the operation of riveting closing the joint completely.

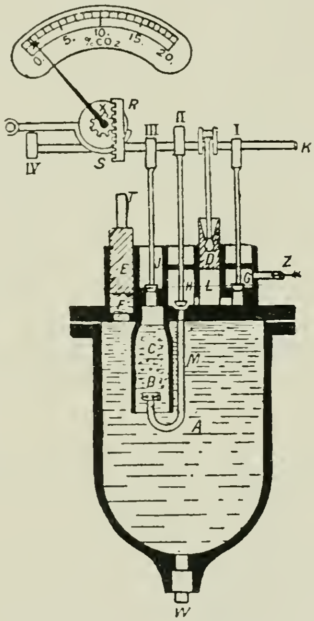


A Spiral Pneumatic Dolly.

THE COOMETER, FOR ANALYZING BOILER FURNACE GASES

This is an automatic apparatus for the boiler room patented in England by Schlatter & Deutsch. The cut is taken and the description here given is adapted from the *Iron Age*. Like a pressure gage, it can be mounted in a convenient position where the stoker can watch its indications and be guided in his firing. Since it makes four records a minute, an almost instant and practically continuous knowledge may be had of the condition of the fire.

A steam motor for continuously rotating the shaft K is an essential part of the apparatus. A connection is made at Z with a small pipe from a point where a fair sample of gas may be withdrawn, and the gas, after passing through a filter, is introduced at constant pressure when the valve G is opened. This valve is operated by the crank I on the shaft K and is opened while the piston D is making its upstroke. Before the latter begins its down stroke the valve G is closed and the valve H is opened by the crank II. The gas, which has been drawn into the chamber L, is then forced out through the tube M and disperser B into the bell C. This bell is in communication with the vessel A, containing a solution which absorbs carbon dioxide. The measured quantity of gas, as determined by the volume of the chamber L, is reduced according to the content of CO_2, and the remainder of the gas, rising as tiny bubbles to the top of the bell C, displaces its volume of the liquid into the chamber F, raising the piston E. At this instant the crank IV releases the brake S, allowing the rack R to descend until it touches the rod T. The amount that R descends is proportional to the volume of CO_2 absorbed, and the pointer, which is rotated through the pinion X by the rack, plays



Section of Coometer.

over a scale calibrated to read directly in per cent. of CO_2. At the lowest position of the piston D and the highest position of the piston E, respectively, the crank disk IV again tightens the brake S against the disk X, restoring the pointer to zero and holding the rack R while the discharge valve J is opened by the crank III, allowing the gas collected in the bell C to be exhausted by the weight of the piston E, and another charge is drawn into the chamber L and analyzed as before. In addition to the indication afforded by the dial a permanent record is made on a drum by perforations on a continuous strip chart which is moved by clockwork. The point records made on this chart are regulated in height by the travel of the rack R, and the fluctuations of the curve traced show how well the firing has been performed. As a matter of course, special care is taken that the materials employed for all parts shall not be corroded or attacked by the gases or liquids, and that the cylinder F shall always contain a neutral solution and not an alkali.

With certain modifications, it is stated that the coometer can be used for registering the analyses of other kinds of gases, such as those in gas engines, gas generators, gas stokers of any kind, and still further applications are possible in chemical, ceramic, sugar and other industries.

DRYING AIR FOR THE BLAST FURNACE

The following we take from an address by James Scott before the Pittsburg Foundrymen's Association:

To-day ore is being got from the Lake Superior regions carrying 13 to 14 per cent. water and less than 50 per cent. of iron; and it is taking two tons of ore to make one ton of iron in many of the furnaces of the Pittsburg district. Some of them require even more than two tons of ore to the ton of iron. In other words, for every ton of iron of 2,240 pounds made, two tons of ore are consumed, and therefore that much more gangue. You get that much irregularity in your blast furnace. Therefore we must use more coke to consume that gangue—we must use more limestone, and limestone is the most refractory material put into the blast furnace.

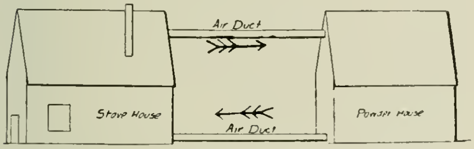
Coke to-day is not as good as it used to be. It is very much higher in sulphur, and much higher in ash, and therefore more of it is required. And the more we use the more sulphur we get, coke giving us the greatest amount of sulphur we get from any material in the blast furnace. Also the larger the volume of coke the greater the variation is going to be in pig-iron. It will be harder for the furnacemen to get a uniform product.

In our American climate everyone knows the benefit of dry air. The blast furnace loses energy. What is the reason? Simply because you are pumping water into it, and where there is appreciable water in the furnace it will lower your silicon and raise your sulphur as well as change your graphite carbon into combined carbon. It makes poor iron. We want to overcome that, but water is one of the elements you cannot decompose unless at the expense of silicon. In order to realize the decomposition that must take place inside of the blast furnace when you are pumping air saturated with water—last year in the month of August, and at the beginning of September, we pumped as high as 11 grains of water to the cubic foot. When you know that a great many of the modern furnaces to-day are pumping as high as 55,000 cubic feet of air a minute and 11 grains of water to the cubic foot, you can figure that there are 20 to 40 tons of water per day pumped in. That water pumped into the blast furnace must be decomposed. How? By the carbon there. If we pump that water in, we are robbing our furnace of heat. If we did not rob the furnace of heat by the pumping in of water, we would have that much more fuel to reduce the oxide of iron from which we get the pig-iron.

We take the air and dry it—we freeze the water out of the air. From eight grains on the average for nine months in the year—six grains per cubic foot in the winter time and just as variable in the summer months—we have on very cold nights taken the moisture down to less than one-half a grain to the cubic foot. In daytime as the temperature rises the moisture rises.

The first great benefit of the dry air—refrigerated air—is that there is no variation. We maintain the air uniformly at one and one-half grains to the cubic foot. We do not pump the large amount of water into our furnace, and therefore we do not require so much coke. And if we do not have to put so much coke in we do not have to take care of the sulphur in that extra amount of coke. Further, we do not have to put in so much limestone to take care of the sulphur; so that we not only have the great advantage of uniformity from dry air, but less trouble from sulphur. This is more important when you consider that all cokes that we have to use to-day are almost 33 per cent. higher in sulphur than they were ten years ago.

If we eliminate the moisture in the atmospheric air we can reduce 15 per cent. more iron ore, and often 18 per cent.; and if we have what we call a favorable mixture on, I have seen as high as 20 per cent. But 15 per cent. can be guaranteed.



FOR THAWING DYNAMITE

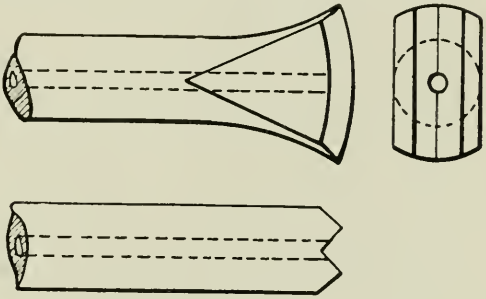
The sketch, from *Engineering-Contracting*, shows an arrangement for thawing dynamite as used by the Tanana Railroad Construction Company, building the Alaska Central Railway. There are two small houses about 20 feet apart and connected by the air boxes at top and bottom, as shown. The dynamite is placed in the house at the right and there is a stove in the house at the left. The air being perfectly free to move naturally, flows in the direction indicated by the arrows, and the desired temperature is obtained in the dynamite house without suddenness of change and without excess of heat.

SUCCESS OF THE GAYLEY DRY BLAST

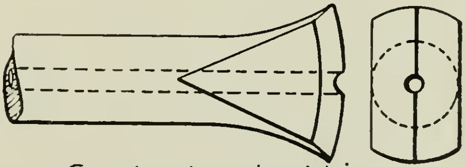
The Warwick furnace No. 2, at Pottstown, Pa., has been equipped for running with dried blast by the Gayley system with highly satisfactory results. There has been an increase of 5 per cent. in the output and a decrease of 11.7 per cent. in the coke consumption per ton of iron and some incidental gains of importance have also developed. The furnace was about to be blown out at the end of August, but since the dry blast installation had then been finished it was hoped that the new method would prolong the life of the furnace for a time sufficient to finish certain urgent contracts for basic iron. This proved true, and it is estimated that the life of a lining is prolonged 32 per cent. by the dry blast method. Moreover, it was found that an unexpectedly high increase in percentage of the desired grade of metal was obtainable.

A NEW ROCK DRILL BIT

The bit here shown, the cut adapted from the *Mining Journal* (London), is the invention of Mr. William Charles Stephens (R. Stephens & Sons). Mr. Stephens introduced the now indispensable hollow drill bit. With the single chisel bit the hole not only takes away a small portion of the cutting edge but also has a tendency to elongate after forging or become more or less oval, thus taking away still more of the chisel edge. The improved bit here shown is called the double parallel edge chisel bit. With the old bit the hole came through the cutting edge of an inverted Λ. With this new bit the apex of the inverted Λ is cut V-wise, so that the hole is not only protected but is unaffected by the forging, no matter how often repeated.



Double chisel bit.



Single edge chisel bit.

The double cutting edge to the chisel bit confers more advantage than at first appears. It can be forged, it is claimed, in about a minute and a half as against twenty minutes to make an X bit by hand. Further, the old type chisel bit occasionally produced a three-sided, and the cross or X bit a five sided hole, while the double-edge chisel bit, no matter at what angle, always gives a perfectly round hole from start to finish and in any kind of rock.

A THOUSAND TONS OF COAL AND A HUNDRED MILLION GALLONS OF WATER A DAY

The records of the great Cunard Atlantic liners, the Lusitania and her so-called sister, the Mauretania, are watched with augmented interest as time passes. It is not denied that the coal consumption is about 1,000 tons every twenty-four hours. It may be a little less or a little more. The bunkers hold 7,000 tons. How much remains in them at the end of each trip is only known by a select few. We take it for granted, however, that each ship burns 1,000 tons of coal every twenty-four hours—that is to say, the contents of the trucks of two 50-car coal trains, one train for the day and the other for the night. As there are twenty-five boilers, each boiler must take 20 tons per day and the same every night.

It may be assumed that, the boilers being Howdenised and the coal good, each pound of coal will make 9 pounds of steam; that is to say, no less than 9,000 tons of steam are made every twenty-four hours, or, neglecting fractions, 375 tons of steam pass per hour through the engines. As the pressure is about 200 pounds absolute, each pound of steam will occupy about 2 cubic feet, which means that 1,680,000 cubic feet of steam pass through the engines every hour.

These are large quantities, but they shrink when compared with the flow of water through the condensers. That will be about fifty times the weight of the feed-water, or $50 \times 9{,}000 = 450{,}000$ tons per twenty-four hours, or 312 tons of water every minute, or 100,800,000 gallons per day. To realize what this means, it will suffice, perhaps, to say that the quantity would represent the water supply at 35 gallons per head per day of a city with nearly three million inhabitants, or almost enough for the city of Paris.

Turning to the furnaces, we have equally astounding figures. Allowing 20 pounds of air per pound of coal, we have 20,000 tons of air passing through the grate bars every day. Taking the temperature of the supply at 100 degrees, we have 14 cubic feet of air to the pound, so that 26,100,000 cubic feet of air enter the furnaces every hour. A pipe 10 feet square would pass this quantity if the speed were that of a great gale—50 miles an hour.—*The Engineer,* London.

OXYGEN REQUIRED FOR BREATHING

The amount of oxygen required varies enormously with the degree of bodily activity, and, to a lesser extent, with the individual concerned. A man at rest uses about 0.3 litre (18 cu. in.) per minute, while severe exertion raises the consumption to 2 litres (122 cu. in.) per minute; a degree of activity corresponding to walking three miles per hour requires rather more than 1 litre (61 cu. in.) per minute.

The volume of air breathed cannot be indefinitely increased, and the breathing of air which is deficient in oxygen is an imperfect stimulus to deeper or more frequent respiration. It is, therefore, necessary that the percentage of oxygen in the air breathed should be maintained as well as the total quantity available for use. It is undesirable that the percentage of oxygen in the air breathed should fall much below that in outside air (21 per cent.), and it is definitely dangerous to breathe a mixture containing as little as 10 per cent. oxygen, especially while doing muscular work. There is no considerable physiological advantage in increasing the percentage of oxygen in the mixture breathed beyond 20 per cent.

The symptoms resulting from breathing air deficient in oxygen are insidious and indefinite. The first obvious symptom, however, especially in persons not particularly directing their attention to the matter, may be sudden loss of consciousness. It is, therefore, absolutely necessary that some definite warning of the failure of oxygen, not dependent on personal vigilance or sensations of giddiness or the like, should be given to the wearer of a rescue apparatus before the percentage of oxygen has fallen to a dangerous limit.

The physiological effects of breathing air containing an excess of carbonic acid are usually obvious. Air containing 5 per cent. causes definite panting, which at 6 or 7 per cent. becomes distress; even 4 per cent. produces unpleasant increase in respiration (hyperpnœa), and greatly reduces the capacity of doing hard work. It may be stated in a general way that 3 per cent. is the maximum permissible, while it is desirable that the percentage should not rise much above 1 per cent. Definite symptoms of poisoning do not appear—at any rate in the course of a few minutes—until the percentage rises to 10 or 15.—*Report of Royal Commission on Safety in Mines.*

COMPRESSED AIR

AND EVERYTHING PNEUMATIC
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KELVIN

Peace and the grace of God abide with thee,
Fallen with weight of everripened days!
Thou canst not hear how men forbear to praise
For grief the world has lost thy majesty.
How shall we more exalt thy fame's degree,
Or to thy memory enduring raise
More lofty tribute than thy Learning lays
Upon thy tomb? What words of eulogy
Are needed more to save thy cherished name
From unremembered annals of the dead?
But with the great of every land we bow
In sorrow, while with loftiest acclaim
Thou to thine everlasting rest are laid
With crown of noble works upon thy brow.

WILBUR MORRIS STEIN.

LIBELING THE AIR COMPRESSOR

A certain *consulting physicist* is filling space in one of our mining exchanges with such statements as the following:

> "The packing of the piston rod and of the piston itself must be extremely tight to withstand air leakage, since the air is a much more volatile material than steam and the leakage problem is much more severe. Thus the friction of modern reciprocating air compressors is great, even in theory, and this friction factor does not diminish under any circumstances with continued use. Many air compressors operate with fully 60 per cent. of the power used in overcoming dead friction in the cylinder and bearings. Hence, the object to be attained in selecting an air compressor is to cut down this friction to as small an extent as possible by constructive detail. The friction of the piston is directly proportional to the diameter of the piston, and the volume of air compressed varies with the square of the diameter. The larger the machine that can be installed, at least as far as cross-section of the cylinder is concerned, the better is the type from an efficiency standpoint."

This belief that air has a mysterious volatility or tenuity is a superstition held by certain users of air and quite widely by those who talk about using it, but there is no foundation of fact for such a belief. Air is no more "volatile," practically no finer in ultimate texture, than steam or water, and no more precautions are required for securing tight piping and non-leaking valves, pistons and stuffing boxes in the case of air, hot or cold, than for steam or water. The statement that many air compressors lose 60 per cent. of their power in friction is absurd in its recklessness. There is no regular air compressor in existence which will show such a loss, and the writer of the above, we believe, would find it impossible to adjust a compressor to show this friction loss and at the same time keep running as a compressor. It happens that the friction loss in a steam-driven air compressor is precisely indicated by the difference in the horsepowers shown by the cards from the air and the steam cylinders. There are Corliss air compressors of the highest efficiency in which the friction loss is under 5 per cent., and 10 per cent. is a sufficient friction allowance for the average machine.

Then, in addition to the above friction loss, there is the loss by clearance, which is explained as follows:

> "No compressor is constructed in which the piston drives out completely the enclosed air. A small space must be left for the operation of the machine, and this space is technically known as the 'clearance volume.' If the clearance volume is large, the compressor operates inefficiently. A certain amount of air is compressed and only a portion of it escapes through the valve. The remainder held in the clearance volume expands on the return stroke of the piston and acts precisely as a spring, and the work done is not available any more than a continued compression and expansion of a spring would be were it fastened to the piston rod outside of the cylinder. For a given cross-section of the piston this clearance volume occupies a percentage of the entire volume in direct proportion to the length of the stroke. On this account the object in air compressor construction is to make the cylinder as long and narrow as possible to cut down the clearance volume."

The loss, so called, in an air compressor on account of the unavoidable clearance is not one of efficiency, but of capacity. A little less than the cylinderful of air is compressed and delivered, but there is practically no power lost for the compression of the air not delivered, as in its re-expansion it helps to propel the piston, or returns the work of its previous compression. Lengthening the stroke does not reduce the clearance in the same proportion, as the actual clearance must be greater with the longer stroke to compensate for the greater springing of the material and the larger play to be allowed with the larger working diameters of pins and journals.

We are told that in a multi-stage compressor "'clearance volumes' are often increased, for there are now several cylinders operating." In any such case only the clearance of the first or intake cylinder counts as to capacity, for whatever passes that cylinder must go through the others.

COMPARISON OF TUNNEL PRACTICE IN SOUTH AFRICA AND COLORADO

In our November issue there appeared an article entitled "Multiple Arrangement of Drills on the Rand," from the *Engineering and Mining Journal.* The publication of this article naturally challenged comparsion with American practice, and the following, by request, was prepared by Mr. W. P. J. Dinsmore, of Denver, Colorado, this also appearing in the *Engineering and Mining Journal,* from whose columns it is here reproduced. The writer calls attention to an article written by himself for *Mine and Quarry,* giving figures covering a rapidly driven tunnel in the Cripple Creek district of Colorado. He then proceeds:

Taking the figures from these two articles we have the following comparative table:

	Rand.	*Cripple Creek.*
Size of bore	5x7 ft.	9x9 ft.
Rate of progress per mo.	225 ft.	375 ft.
Number of machines used shift	3	2
Number of men employed per shift	8	6
Number of holes drilled per round	15	20
Length of shift, hours	8	8
Max. distance over which spoil had to be trammed	800 ft.	8500 ft.

From the above figures we can strike averages and derive the following:

	Rand.	*Cripple Creek.*
Lineal feet advance per shift	2.43	4.03
Cu. ft. rock broken per shift	85.05	326.43
Percentage of advance, lineal feet	60%	1.66
Percentage of advance, cu. ft.	26%	3.84
Percentage of machines used	150%	0.66
Percentage of men used	133%	0.75
Percentage of holes drilled per round	75%	1.33

The work on the Rand was carried on with a greater number of men and machines. The article in the *Journal* also brings out the fact that the Rand tunnel was driven to single track size to be later widened to accommodate double tracks. Not so with the Cripple Creek tunnel, which was at all times kept up to its required width.

That there must be causes for the difference in speed as shown above, is self-evident. These causes must rest upon four things, viz., the hardness of the rock; the method employed in doing the work; the efficiency of the men; and the efficiency of the machinery.

The rock encountered in the Rand tunnel was undoubtedly harder on the average than that in the Cripple Creek tunnel, though some of the rock at Cripple Creek was probably as hard. The cylinder diameter of the drills used in the Rand tunnel was 3¾ in. and that of the Cripple Creek drills was 3⅛ in. The drills in the Rand tunnel put in on an average five holes each per shift, while those in the Cripple Creek tunnel averaged 10 holes each per shift. In view of these facts it would hardly seem that the rock, even if much harder on the Rand, could be held entirely responsible for the difference in the speed accomplished.

It may be that the Rand tunnel was being widened at the same time that the heading was being advanced, in which case it is possible that the tracks over which the spoil from the heading was being trammed were more or less blocked by the drills and the broken rock at the point where widening was in process. This blocking, if extensive enough, might well be the cause of delays in getting the spoil away from the heading and thus delay the work of advancing the heading. From the data that we have at hand, this would not seem to be the case, and it would appear that a round of holes was drilled and shot each shift. Therefore, it would not be right to charge delays to this until further confirming information be secured.

The fact that the Rand tunnel was driven smaller than the Cripple Creek tunnel may also account for some delay. While it would naturally seem that a small tunnel could be driven faster than a large one, at the same time this has not always been the case. The larger tunnel in some cases can be driven faster than the smaller tunnel owing to the fact that the rock breaks more easily. The powder having a larger face to work on, consequently breaks deeper per round, and the larger tunnel also gives more room in which the drillmen and shovelers may work, so that a round of holes is drilled fully as quickly in the larger tunnel, or even more quickly, and the additional size gives the shovelers the additional room necessary to get out a larger amount of rock.

The difference in the speed of drilling can hardly be charged up to the hardness of the rock. Therefore, it would seem that it must be charged either to the method employed, i. e., that of driving a small tunnel instead of a larger tunnel, or to the efficiency of the men or machines employed.

THE MECHANICAL MISSIONARY

The power-driven rock drill is a mechanical missionary, and one of prolific accomplishment. It is a doer of good in large measure, so that the works of the conscious, purposeful, professional beneficent are belittled by comparison with it. The wealthiest man who ever lived could not have given to the world a tithe of what this thumping, punching and apparently rough-and-ready device has contributed. Its work is essentially the simplest that could be thought of, merely to perforate Earth's cuticle in predetermined spots. Only to make the holes is all that is demanded, and no precision of either location or dimension is required. Yet this simple operation and the apparatus which has made it easy to do afford, perhaps, the most striking enforcement of the dictum that every cause is productive of more than one effect. In the case of the rock drill as a cause the effects of it are innumerable and many of them reach far beyond our ken.

The first notable work of the rock drill was in the driving of the Hoosac tunnel, a task so hopeless before its advent that the time of the tunnel's completion was suggested by the Autocrat of the Breakfast Table as the end of all things and the period for the donning of our ascension robes. The tunnel was easily enough bored when the rock drill got at it, and the tunnels it has driven since and the open cuts are only to be measured by the thousands of miles.

But that was only the beginning, and only one of the many special lines of employment which the rock drill has made for itself. If it now has one specialty upon which it may pride itself more than another, and by reason of which all mankind are most indebted to it, the specialty is mining, the unlocking of the treasures of Earth. Whether it is lead or silver or gold, or the vastly more valuable copper and coal and iron, these all it makes free to man to use as he will for every purpose that may be devised. The rock drill works to the greatest depths and has been the sole means of reaching the greatest depths below the surface, and it works equally well in the open to the limits of accessibility in the mountains. In its unearthing of treasure it goes to the remotest corners of the globe, so that the one special area in which it is most numerously employed to-day is not in the seats of civilization, ancient or modern, but in the farther corner of the dark and so long unknown continent. On the Rand in South Africa, and not in the metropolis of either the Old or the New World is where the rock drill is the most numerous and the busiest. And it goes not alone to the remote and hitherto inaccessible and uninhabitable regions where the mineral treasures are most likely to be found stored. It is always in touch with the spirit of the age and draws after it all the agencies and the facilities of civilization and plants them everywhere to stay. It is banishing the savage from the Earth. The railroads, which lace the continents, and the canals, from sea to sea, are the creations of the rock drill, and in the promotion of universal intercourse and mutual knowledge and a recognition and full appreciation of the common interests of the race it is foremost.

As illustrative of the diversity of effects which may follow the single cause it is to be remembered that the air compressor, as a machine of established manufacture, became so upon the demand of the original rock drill. For a long time the almost sole employment of the compressors, when first built in numbers and of respectable size and efficiency, was the driving of the rock drills which had called them into being, the field of their first activities being almost exclusively in mining and tunnel work. The supply of compressed air by the presence of these compressors being made easily attainable, the diversifying employments and the multitudinous variety of compressed air tools and appliances rapidly developed.—*Cassier's Magazine.*

In 1906 the production of natural gas in the United States was 388,842,562,000 cubic feet, or 9,396,864 short tons, the value of which, reckoned at $5 per ton, was $46,984,320.

UNPROMISING LIQUID AIR

At a recent meeting of the South Wales Institute of Engineers, liquid air having been casings of the machine, while the fan will spoken of for use in a mine rescue apparatus, had made him a little skeptical as to the practical usefulness of various adaptations of liquid air. The great thing was to have the liquid air at hand when wanted, and always ready in real emergency. For power purposes, liquid air could not be produced more cheaply than by expending one pound of coal for every pound of liquid air, whereas one pound of coal could be got to raise ten pounds of steam; so that one pound of coal would produce power the equivalent of at least twenty pounds of liquid air. Then for refrigerating purposes, liquid air compared unfavorably with ice, because one pound of coal would produce from fifteen to eighteen pounds of ice, and, weight for weight, ice was as good a refrigerating agency as liquid air. It did not produce such an intense cold, but as much useful cold could be gotten out of a given quantity of ice as from the same quantity of liquid air, and, as he had said, it required fifteen times as much coal to produce a given quantity of liquid air as it did to produce a similar quantity of ice. The only important industrial use to which liquid air had been put was in the production of oxygen by a process of distillation, but on the scientific side it had been the means of discovering important properties of substances at low temperature, including those of the emanations of radium.

QUESTIONS AND ANSWERS

Q.: How many cubic feet of free air per minute will flow through a 1-inch and also a 2-inch pipe, 1,000 feet long, under 117.6 and 157 pounds, gage, pressure?

A.: The volume of air flowing through a pipe in a minute, or other period of time, depends upon both the initial and the terminal pressures. Our working formula is as follows:

$$v = \sqrt{\frac{2,000d^5(p_1^2 - p_2^2)}{l}}$$

in which

v=cubic feet of free air per minute.
d=diameter of pipe in inches.

l=length of pipe in feet.
p_1=initial absolute pressure.
p_2=terminal absolute pressure.

The above formula may be transformed to get the different values as follows:

$$l = \frac{2{,}000 d^5 (p^2_1 - p^2_2)}{v^2}$$

$$d^5 = \frac{v^2 l}{2{,}000\ (p^2_1 - p^2_2)}$$

$$d = \sqrt[5]{\frac{v^2 l}{2{,}000\ (p^2_1 - p^2_2)}}$$

$$(p^2_1 - p^2_2) = \frac{v^2 l}{2{,}000\ d^5}$$

In the present question with the first set of conditions, that is, 1-inch pipe and 117.6 initial pressure, we assume a loss of pressure of 10 pounds, which would make the initial absolute pressure, or p_1, 117.6+14=132.3, and the terminal absolute pressure, or p_2, 132.3—10=122.3. Then applying these values in the formula, we have:

$$v = \sqrt{\frac{2{,}000 \times 1^5 \times (132.3^2 - 122.3^2)}{1{,}000}}$$

$$v = \sqrt{\frac{2{,}000 \times 1 \times (17{,}503.29 - 14{,}957.29)}{1{,}000}}$$

$$v = \sqrt{\frac{2{,}000 \times 1 \times 2{,}546}{1{,}000}}$$

$$v = \sqrt{5{,}092}$$

v=71.35 cubic feet per minute.

With the 2-inch pipe, 157 pounds, gage, pressure and assuming a loss of 15 pounds, our solution would be as follows: 157 gage + 14.7=171.7 absolute initial pressure and 171.7—15=156.7 absolute terminal pressure. Then

$$v = \sqrt{\frac{2{,}000 \times 2^5 \times (171.7^2 - 156.7^2)}{1{,}000}}$$

$$v = \sqrt{\frac{2{,}000 \times 32 \times (29{,}480.89 - 24{,}554.89)}{1{,}000}}$$

$$v = \sqrt{\frac{2{,}000 \times 32 \times 4{,}926}{1{,}000}}$$

$$v = \sqrt{315{,}264}$$

v=561.48 cubic feet per minute.

W. M. S., Batson, Texas. *Q.:* I understand the law is that, the temperature remaining the same, the volume of a given quantity of air is inversely as the pressure which it bears, but I do not fully comprehend this. By the above law, doubling the pressure would halve the volume of air, the pressure remaining the same, but in a certain Air Compressor Catalogue appears this extract from COMPRESSED AIR: "The diagram shows that when a volume of free air is compressed adiabatically to 21 atmospheres (294 pounds, gage pressure) it will have a volume of a little more than one-tenth." I understand that adiabatic compression would leave a larger volume than isothermal, but should there be that difference?

A.: In all these operations it is to be remembered that only absolute pressures and temperatures are dealt with. In compressing to 21 atmospheres the ratio of absolute pressures would be 1-21=.0476 and the ratio of volumes under isothermal compression would be the same, but the ratio of volumes at the termination of adiabatic compression to 21 atmospheres would be .1149, or reciprocally 8.668 instead of 21, so that the statement that the volume would be "a little more than one-tenth" was not an exaggeration. Approximately the same result may be reached in corroboration of the above by a different process. In adiabatic compression from 1 to 21 atmospheres from an initial temperature of 60 degrees the final absolute temperature would be 1,259 degrees, and the ratio of initial and final temperatures would be $\frac{60+461}{1259}$=.4138. Then the ratio of volumes would be 1:.4138::21:8.689, which is quite near the 8.668 found above. It is expected that a later issue of COMPRESSED AIR will contain formulas, tables and diagrams which will be of great assistance in computing the relative pressures, volumes and temperatures which occur in air compression.

TRADE PUBLICATIONS

The Fuller-Lehigh Pulverizer Mill, Lehigh Car, Wheel and Axle Works, Fullerton, Pa., 44 pages 9x12 inches. This expensively printed publication, with numerous half-tones, describes the pulverizer mill to its minutest detail, and gives accounts of various installations.

The Westinghouse Storage Battery Auto-Truck for Industrial Railways. The Westinghouse Machine Company, East Pittsburg, Pa., 18 pages 6x9 inches. This pamphlet, with fine half-tones and not overwritten, describes a line of flat trucks for use in transporting working material in factories and yards upon the tracks, usually narrow-gauge, of "industrial" railways. Everything is below the flat top of the truck, but readily accessible. At a nominal cost for power, and not requiring skill to operate, the car moves itself and load wherever required.

The Treatment of Belts and Ropes for Service and Profits. Cling-Surface Company, Buffalo, N. Y. 88 pages 4½x7 inches. Well described by the title. A great variety of conditions and applications of belting are treated of.

The "De La Vergne" Two Cycle Vertical Oil Engine, De La Vergne Machine Company, foot of East 138th street, New York. This is an 8-page folder 4x9 inches, describing a new line of engines built by this company. The engine uses kerosene or fuel oil, about a pint per horsepower hour. There is no carburetor and no valve motion, and the engine is one of the simplest ever devised. It is safe, reliable, economical, and runs at high speed, occupying little space for the power developed.

Abbreviated Catalogue, The Whitney Manufacturing Company, Hartford, Conn. 12 pages 6x9 inches. Shows chains, "Whitney" machine keys, key-seat cutters, checks, tapping devices, millers, grinders, etc., made by the company.

Small Steam Driven Air Compressors. Ingersoll-Rand Company, New York; 38 pages, 6x9 inches. This catalog, handsomely printed and copiously illustrated, describes the smallest steam driven compressors of both the Ingersoll and the Rand types with the latest improvements on each as built by the present company. The capacities range from 30 to 500 cubic feet of free air per minute and the gage pressures from 15 to 100 pounds.

KELVIN AS AN INVENTOR

There are three kinds of inventor—the man who comes on discoveries accidentally, generally when looking for something else; the enthusiast, often a little ignorant, who works at a problem with a kind of instinct, and solves it by a stroke of genius which no one can explain; and the educated technologist, who, finding a door difficult to open, merely selects from the given stock of knowledge the proper key to open it. Kelvin belonged to the last category. His great inventions, such as his compass, his mirror galvanometer, his syphon recorder, and his electrical measuring instruments, all depend on alterations in degree of something that went before. He also developed his inventions by a curious method. He never seems to have been able to sit down and make a drawing of, say, an instrument. He would have an experimental model made from instructions, and would then alter it about until it satisfied him, and then it would be copied as it was. The result was that all his instruments looked as if they ought to be re-designed by a good engineering draughtsman. Kelvin's inventions were often great, but it was because his available knowledge was great, and, though they would be remarkable for an ordinary man, they are really dwarfed by his greatness in other directions.—*The Engineer.*

THE DEGRADATION OF NIAGARA

It is many years now since the Niagara River was first called upon to pay tribute to modern industrial needs, and was, as the phrase goes, "harnessed" to an alternator, as though it were a horse harnessed to a whim. The draught of power is measured now by the million horse-power, but up to the present the majestic Falls have remained to all appearances unharmed, and nothing can be said against the wise and prudent use of the vast supply of energy thus reclaimed from Nature's stores.

We learn, however, from the American papers that the amenities of the Falls are endangered in another way altogether. The authorities of the city of Niagara Falls have commissioned the General Electric Company to install batteries—we might call them parks—of large searchlights, with which to illuminate the Falls, and the work is actually in progress. Beams of all the colors of the rainbow are to be projected upon the falling waters, under the control of "an operator manipulating a keyboard" so as "to obtain a thoroughly artistic interpretation of the color scheme"—*artistic!* To crown this scheme of vulgarization, the Falls are to be assisted—faked—boosted—for their natural resources are inadequate to satisfy the doers of this vandalism. In fact, a steam boiler is to be used, to discharge "clouds of steam" from pipes "to augment the mists," so that "artistic" cloud effects may be produced, with the aid of the searchlights. Bombs will be thrown also, to burst over the Falls and emit heavy clouds of smoke or a shower of . . . *confetti.*

Alas! How are the mighty fallen! The monster has been harnessed; now it shall be tortured, to make a Yankee holiday. Shame!—*Electrical Review,* London.

REAL RAILROAD VALUES

The following is the opening paragraph of a valuable, suggestive and informing address recently delivered by Robert Mather before the Chicago Association of Commerce:

If the rails of the land should melt over night, the loss to-mrrow morning would be less in the falling quotations of railroad bonds and stocks than in the utter destruction of the values on farms and in mines and mills and factories that to-day we count as the nation's wealth. Such sudden and miraculous solution of the problem is, of course, unlikely; at least it has not yet been advocated in Presidential speech or message. But any diminution of the industrial efficiency of our transportation lines would affect in like manner, though in lesser degree, all the varied interests that would go down to destruction with the annihilation of those lines. It is not alone, therefore, the few thousands who own the securities of the railroads, or the million and a half employees engaged in their operations, or the ten millions whom the wages of these employees support, that are directly and peculiarly interested in the proper solution of the railroad problem. The question comes home as well to the pockets of the millions of farmers and miners and millers and manufacturers and merchandisers, with all their added millions of dependents. In short, it is a question that touches us all, not because the charge for transportation is a large element in the cost of what we consume, but because without efficient railroad transportation our commerce could not be profitable. The gross earnings of all our railroads for the fiscal year ending June 30, 1907, were $2,325,765,167. Divided among the population this would be $25 each. A 33 1-3 per cent. reduction in freight and passenger rates would mean $8 per annum for each of us, but a reduction by one-third of the capacity of our transportation lines to move the tonnage of the country would mean ruin to us all.

A BIG BLAST SAVES $10,000

C. F. Johnson, who has the grading contract for eighty-five miles of the Chicago, Milwaukee & St. Paul Railroad west of Ellensburg, Wash., recently cleared $10,000 in a fraction of a minute. He sent $7,000 up in smoke and $17,000 worth of grading was done in a jiffy.

Alexander Holman, who directed the work, tells the story as follows:

"It is a little more than a year ago that I began sizing up that rock hump and figured on the best way to handle it. I got my men to work, and by slow and tedious drilling we excavated eight pockets for the powder. We ran eight small tunnels, just big enough for the men to work in, directly into the face of the rock shoulder. When the right point was reached we ran tunnels to the right and left.

"We stowed away in the eight pockets 1,771 kegs of black powder and dynamite enough to bring the total up to the equivalent of 1,800 kegs. This represented about 55,000 pounds of powder. When the shot was ready for the electric wires the cost was $7,000. Naturally, the greatest care was taken with the wiring. In order to make sure of accurate work, I rigged two batteries and set them away up the side of the mountain behind the biggest tree we could find. I want you to note that we piled all our drills, hammers and other tools at a point a considerable distance above the mine and behind another big tree. A mighty curious thing happened to that pile of tools, as I will tell you later.

"When all was ready and everybody warned in all directions I touched the buttons of the two batteries, and then things happened quickly. The whole point of rock trembled, and when the great bulk of the twenty thousand yards of stone were hurled into the lake it created a sort of a tidal wave that made the water rise three feet on the shore opposite more than a mile away. The water marking on the rock on the lake shore immediately adjoining the blast showed that the water surged back and swelled up six feet.

"All we have to do now with that hump is to roll out 5,000 yards of rock, and then we stand 25,000 yards to the good. Instead of the slope being shattered so that we would have to take down and out a lot of dead work, the fact is that the slope is just as perfect as if the cut had been made by piecemeal. Of course, the fact that we will have no dead work is unusual, for some can be safely counted on in blasts of this size.

"Now, the curious thing about that pile of tools was this: A rock that will easily weigh several tons was thrown high enough to go over the top of a group of fir trees that stood immediately above the blast. It never scratched the trees nearest the blast, but in coming down it side swiped a big fir two feet through, sending it down with a crash, and lit squarely on top of the pile of tools, with a result that can be imagined."

NOTES

The name of *Technical Literature* has been changed to *Engineering Digest*, which more accurately describes the scope of the publication. It collects, selects and condenses a wide variety of fresh technical matter and is already a valuable addition to the means of information accessible to the up-to-date technical man whatever may be his specialty.

The Mining Reporter, weekly, and *Ores and Metals*, semi-monthly, both of Denver, are now consolidated into *Mining Science*. Geo. J. Bancroft, M. E., is to be editor-in-chief of the new publication with W. H. Graves and H. J. Baron, former editors of *Ores and Metals* and of *The Mining Reporter*, respectively, as associate editors.

A new channel is to be excavated for the Sturgeon River, Michigan, to carry it away from the Loretto mine. A considerable quantity of rock and 500,000 cubic yards of earth will have to be moved. This will release a large body of ore directly under the present bed of the stream.

Sunken ships may now be refloated by means of acetylene gas. An experiment was recently successfully tried on a ten-ton boat in the River Seine. The boat was raised by means of small balloons inflated below the water with acetylene gas immediately generated from the solid carbide of calcium by the action of the water, which made the operation practically automatic.

The Rove tunnel, for the canal from Marseilles to the Rhone, will be the largest, but not the longest, in the world. In cross-section it will be 72 feet wide and 46 feet high, with a 6½-foot roadway on each side for an electric railway. The material to be removed will be double that of the Simplon tunnel. The estimated cost is about $7,000,000 and seven years will be required for the work.

When an issuing U. S. patent has more than five claims those above that number are now not printed in the *Patent Office Gazette*. This quite naturally reduces the bulk of each issue, reduces also the cost of printing and is in every way to be commended. The claims printed are always sufficient to give an idea of the patent, although even those are never fully intelligible without a copy of the specifications and drawings, which any one may have, with, of course, all the claims, for five cents. And yet there are some to find fault with this exercise of common sense in the Patent Office.

For years, says the *Iron and Coal Trades Review*, the steel industry has confidently expected to see a fulfilment of the prediction made long ago that "the open-hearth process will go to the funeral of the Bessemer." Recent developments indicate rather clearly that the function will be a wedding instead of a funeral, a vastly more happy occurrence. The duplex process is rapidly gaining in favor, and the details are being worked out in different ways by different metallurgists. It is more a matter of appliances and manipulation than processes, as the metallurgical work is laid out very clearly.—*The Engineer.*

The mechanical engineer is one who by science and by art so adapts and applies the physical properties of matter and so controls the forces which act through them as to serve the use and convenience of man and to advance his economic and material welfare. He does this mainly by storing and liberating motor energy through machines and apparatus which he designs and installs and operates for the purpose of fostering and developing the processes of industrial production which use and require such power upon a large scale.—*Pres. Hutton before the Amer. Soc. Mech. Eng.*

Our readers will remember the striking pictures shown in our December issue of the caissons which are being sunk under the Seine for one of the Paris subways. We regret to note that a serious accident has occurred in the placing of them in position, entailing loss of life and serious additional cost and delay. On December 23 one of the sections, from some cause, became displaced and the outrushing air caught five of the workmen, crushing and killing them instantly. The entire workings were immediately flooded so that the total damage is not known, and the righting of things may be a novel and in any case a serious engineering problem.

One of Kelvin's most astonishing characteristics was his avidity for work. He was as enthusiastic at eighty-three as at twenty-three, and he seemed to work always. He really loved work, and he never tired of it. He was a standing refutation of the theory that a man does no good work after forty. It is much more likely that we all get lazy at forty to forty-five; but those who work hard from forty to fifty without succumbing, remain active all their lives, and probably prolong their active existence considerably.—*The Engineer.*

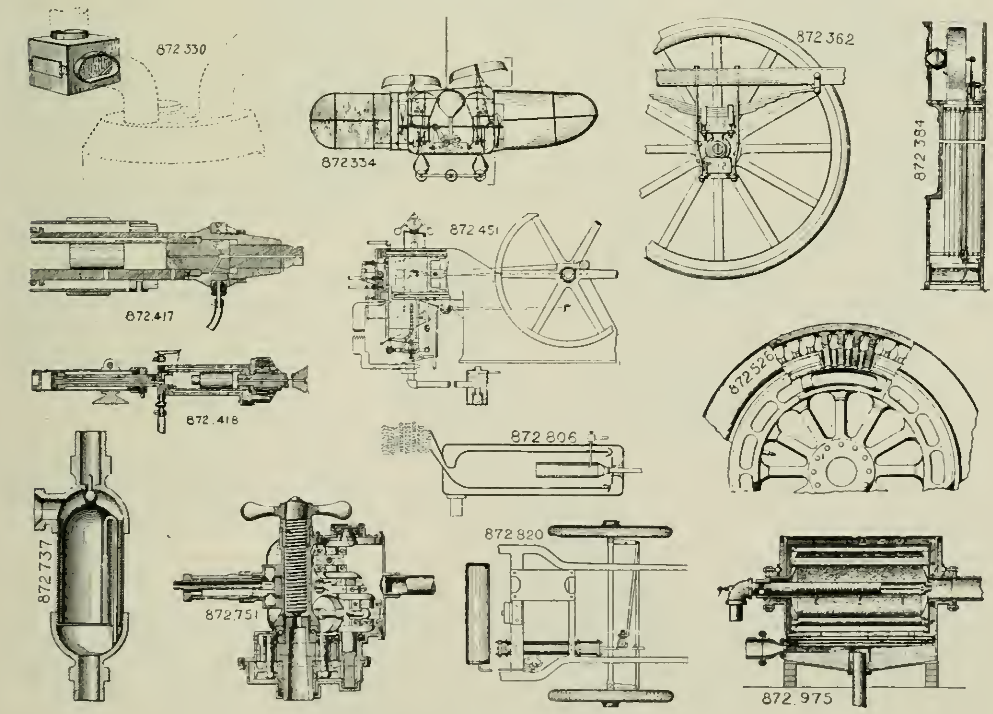
LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

DECEMBER 3.

872,330 AIR-MOISTENER FOR FURNACES. William A. Cunningham, Winona, Minn.

872,334. AIR-SHIP. Aurelio S. Fadda and John Di Lorenzo, Pittsburg, Pa.



Pneumatic Patents December 3.

872,362. PNEUMATIC SPRING AND SHOCK-ABSORBER FOR MOTOR-VEHICLES. Albert L. Muren, Belleville, Ill.

872,384. HUMIDIFIER. Joseph J. Smith, New York, N. Y.

872,417. ROCK-DRILLING MACHINE OR ENGINE. Henry Hellman and Lewis C. Bayles, Johannesburg, Transvaal, South Africa.

872,418. ROCK-DRILLING MACHINE OR ENGINE. Henry Hellman and Lewis C. Bayles, Johannesburg, South Africa.

872,451. CLEARANCE-CONTROLLING MECHANISM FOR COMPRESSORS AND MOTORS. Sidney A. Reeve, Worcester, Mass.

872,526. PROTECTED PNEUMATIC TIRE. Carl G. Lotave, Denver, Colo.

872,737. AIR-VALVE. Doctor F. Morgan, Chicago, Ill.

872,751. PNEUMATIC MOTOR. William F. Rothe, East St. Louis, Ill.

872,806. ELASTIC-FLUID TURBINE-ENGINE. Sebastian Ziani de Ferranti, Hampstead, London, England.

872,820. AIR GUIDE OR STEERING DEVICE FOR AUTOMOBILES. James T. Johnson, Memphis, Tenn.

872,868. PNEUMATIC STRAW-STACKER. James A. Walsh, Indianapolis, Ind.

872,975. APPARATUS FOR WASHING GAS. Charles E. Sargent, Chicago, Ill.

DECEMBER 10.

873,051. ELASTIC-FLUID TURBINE. Oscar Junggren, Schenectady, N. Y.

873,065. AIR-PUMP. George H. Mohler, Fremont, Nebr.

873,069. CAISSON CONSTRUCTION. A. Z. McLeod, New York, N. Y.

873,153. SYSTEM FOR VENTILATING PASSENGER-CARS. Nelson S. Mercer, Omaha, Nebr.

873,345. PNEUMATIC GROUT MIXING AND DISCHARGING APPARATUS. William L. Canniff, New York, N. Y.

873,476. VALVE FOR FLUIDS UNDER PRESSURE. Harry Woods, Steubenville, Ohio.

873,517. COMPRESSED-AIR-CUSHION BLOCK FOR PILING. Clinton C. De Witt, St. Louis, Mo.

873,531. PNEUMATIC-DESPATCH APPARATUS. Edmond A. Fordyce, Boston, Mass.

873,542. AERIAL VESSEL. George Halliday, Superior, Wis.

873,565. TERMINAL FOR PNEUMATIC-DESPATCH-TUBE APPARATUS. Isaac W. Litchfield, Boston, Mass.

873,590. PNEUMATIC-DESPATCH-TUBE APPARATUS. Albert W. Pearsall, Lowell, Mass.

873,688. COMBINED WET AND DRY AIR PUMP. Royal D. Tomlinson, Milwaukee, Wis.

DECEMBER 17.

873,725. PNEUMATICALLY-OPERATED GONG. Fred B. Corey, Schenectady, N. Y.

873,740. PNEUMATIC-DESPATCH-TUBE APPARATUS. Edmond A. Fordyce, Boston, Mass.

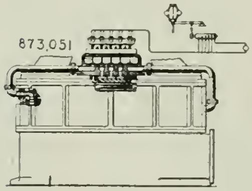
873,776. REVERSING MECHANISM. Sven T. Nelson, Chicago, Ill.

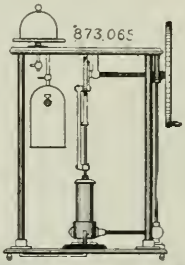
873,801. SWIVEL FOR ROCK-DRILLS. Samuel A. Sizemore, Leadwood, Mo.

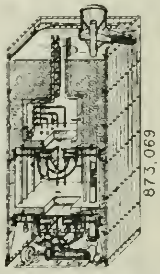
873,813. ROCK-DRILL AND OTHER PERCUSSION-TOOL. Thomas Warsop, Coniston, England.

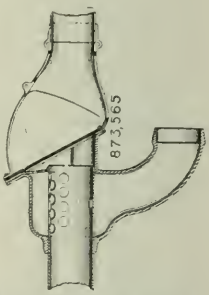
873,829. PNEUMATIC STACKER. Byron G. Baker, Minneapolis, Minn.

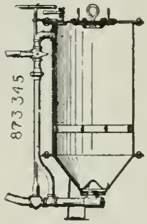
873,924. HUMIDIFYING AND AIR-MOISTENING APPARATUS. Stuart W. Cramer, Charlotte, N. C.

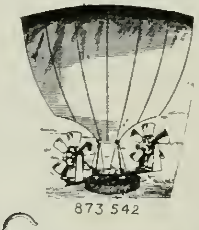


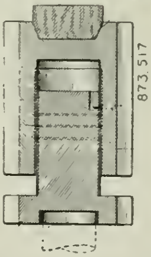


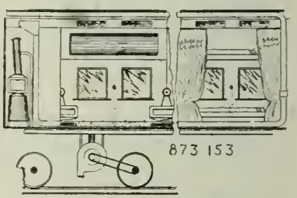


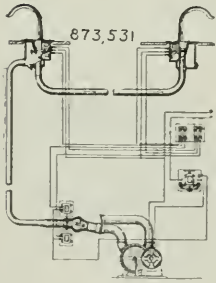


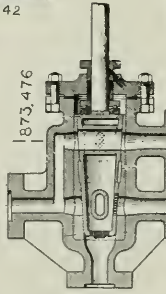


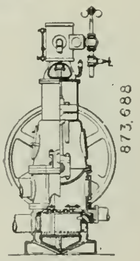


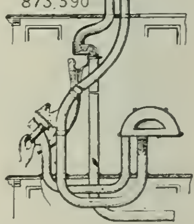












Pneumatic Patents December 10.

873,938. PNEUMATIC HAMMER. Martin Hardsocg, Ottumwa, Iowa.

873,947. TRAIN-PIPE COUPLING. George E. Kelly and George F. Royer, Wilkes-Barre, Pa.

873,948. TRAIN-PIPE COUPLING. George E. Kelly and George F. Royer, Wilkes-Barre, Pa.

873,984. COMPRESSED-FLUID CHARGING AND DISCHARGING DEVICE. Gabriel A. Bobrick, Los Angeles, Cal.

874,034. DISCHARGE-VALVE FOR FLUID-COMPRESSORS. William Prellwitz, Easton, Pa.

874,054. AIR-BRAKE SYSTEM. Frank H. Dukesmith, Meadville, Pa.

874,065. HAIR-DRYING APPARATUS. Richard Grape, New York, N. Y.

874,066. ATMOSPHERIC CLOTHES-POUNDER, Samuel D. Griffith, Curwensville, Pa.

874,137. AUTOMATIC PRESSURE-REGULATOR. Charles P. Tolman, New York, N. Y.

874,212. PNEUMATIC FAN. Charles Kuderer, Allegheny, Pa.

874,229. CONTROLLING MECHANISM. John J. Nef, Chicago, Ill.

In a fluid pressure governor, the combination of a reciprocating rod, means for moving the same in one direction by fluid pressure, a spring for moving the rod in the opposite direction, toggle-members pivotally connected at one end, a pivotal support for the other end of one of said members, a support for the other end of the other member permitting axial movement of said member as the toggle is buckled, parts on said rod adapted to engage the toggle when the rod is reciprocated and between which the toggle can move free of the rod, a spring acting on the toggle to continue movement thereof started by one of said parts, a movable circuit-controller independently pivoted on said pivotal support for one of the members of the toggle, and a loose connection between said toggle-member and controller whereby the former actuates the latter when operated by the spring acting thereon, substantially as set forth.

874,261. GRADUATED-RELEASE-VALVE MECHANISM FOR FLUID-PRESSURE BRAKES. Walter V. Turner, Wilkinsburg, Pa.

DECEMBER 24.

874,455. ROCK-DRILL. Frederick V. W. Swanton and Burt Price, Braamfontain, Johannesburg, Transvaal.

874,488. OIL-BURNER. Joseph L. Causey, Kansas City, Mo.

874,499. HAND ROCK-DRILL. Charles H. Gunn, Oroville, Cal.

874,603. ROCK-DRILLING MACHINE. Alva D. Lee, Brookline, and Francis J. E. Nelson, Jr., East Boston, Mass.

874,622. PNEUMATIC SIGNAL FOR RAILWAY-CROSSINGS. James W. Pipkin and Hillard S. Mitchell, Wilton, Ark.

874,771. COMPRESSED-AIR MOTOR. Thomas L. Jones, Hamburg, Germany.

874,823. FLUID-PRESSURE ENGINE. Irvin E. Barricklow, Antioch, Cal.

874,894. DRILL. George E. Lynch, Columbus, Ohio.

DECEMBER 31.

874,960. AIR-PUMP. Benjamin Hamann, Detroit, Minn.

874,986. VACUUM-PRODUCING APPARATUS. Charles A. Parsons, Newcastle-upon-Tyne, England.

875,010. LAMP FOR BURNING CARBURETTED AIR. Frank W. Suter, London, England.

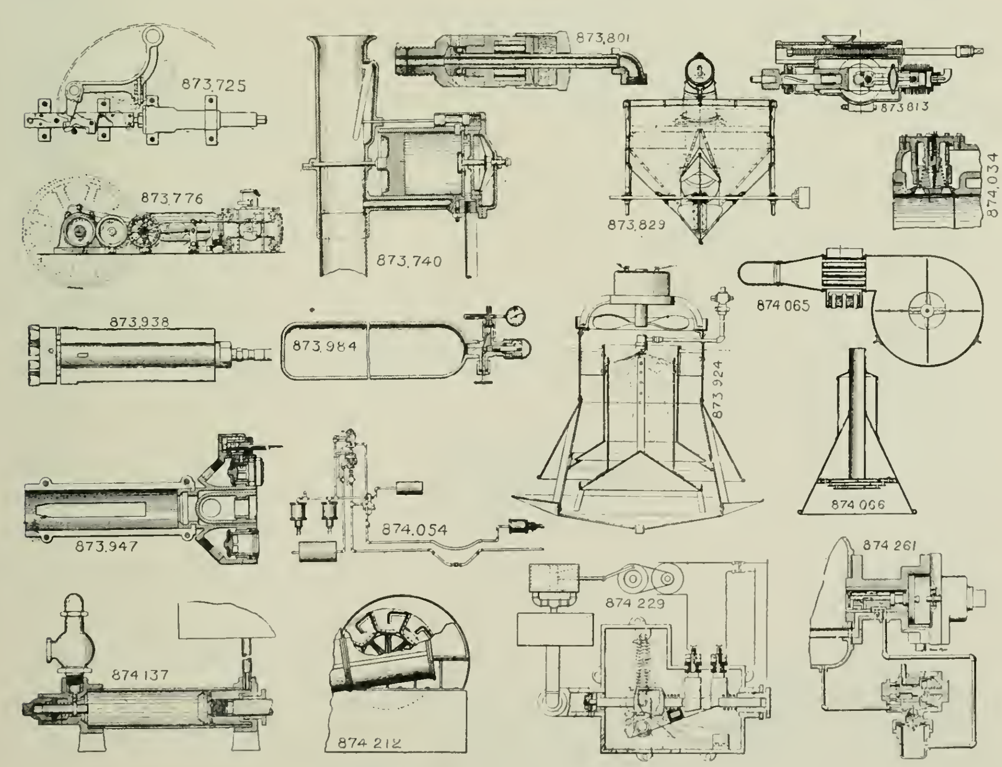
875,042. WAVE-MOTOR. Edward J. Bissell, Bay City, Mich.

875,111. ELASTIC-FLUID TURBINE. Frederick Samuelson, Rugby, England.

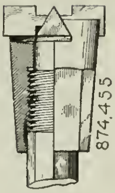
875,175. AIR AND GAS MIXER. William H. Hess, Dewey, Okla.

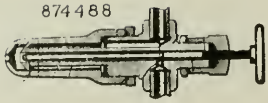
875,277. ROTARY VALVE FOR AIR-COMPRESSORS. George W. Meyer, Sparrows Point, Md.

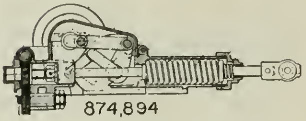
875,446. PUMP FOR VACUUM-CLEANERS. Arthur Mestitz, Raudnitz, Austria-Hungary.

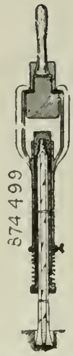


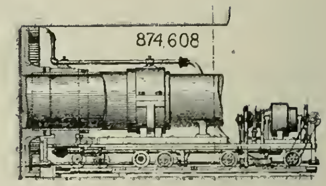
Pneumatic Patents December 17.

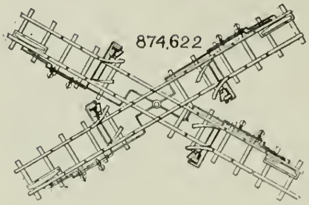


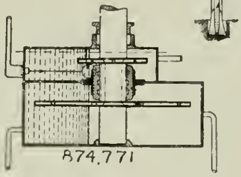


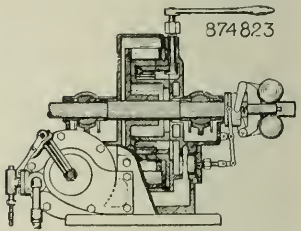












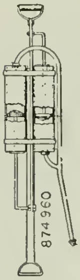
Pneumatic Patents December 24.

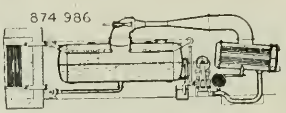
875,468. ACETYLENE-GAS GENERATOR. Frank E. Stover and Charles L. Darnall, Chattanooga, Tenn.

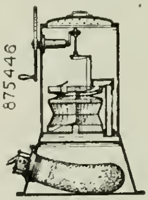
875,543. AUTOMATIC BRAKE. James Lynch, Van Buren, Ark.

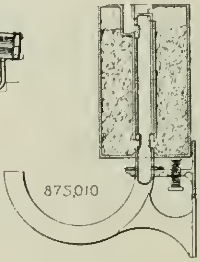
875,664. TUNNELING-MACHINE. John P. Karns, Boulder, Colo.

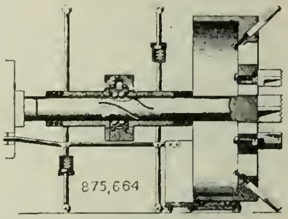
12,737 (Russian). FLUID-PRESSURE SYSTEM. Walter J. Richards, Milwaukee, Wis.

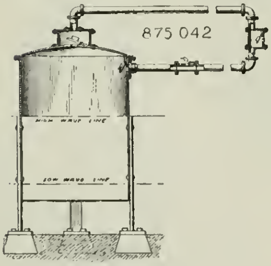


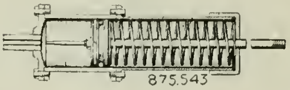


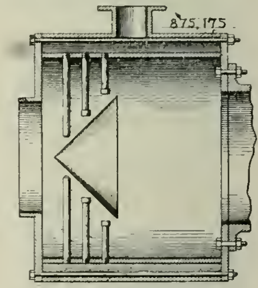


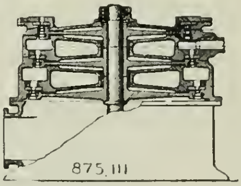


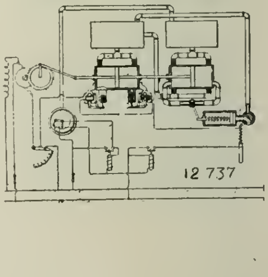


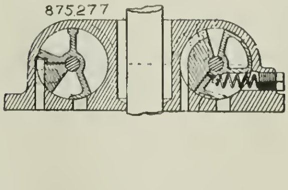


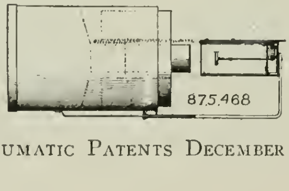












Pneumatic Patents December 31.

COMPRESSED AIR
AND EVERYTHING PNEUMATIC

Vol. XIII MARCH, 1908 No. 3

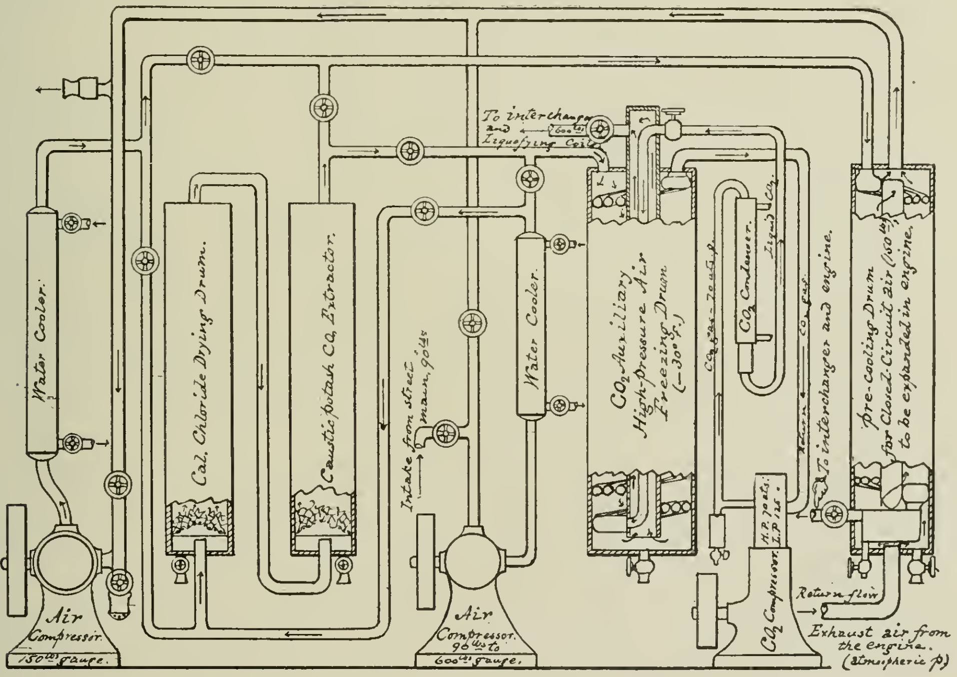
PLACE'S AIR-LIQUEFYING EXPANSION ENGINE

SOME INDICATOR CARDS TAKEN AT LOW TEMPERATURES FROM THE AIR EXPANDING ENGINE OF THE AIR-LIQUEFYING PLANT AT NORWICH, CONN.

BY J. F. PLACE, M. E.

Having recently completed and put into successful operation an air-liquefying plant for the New England Refrigerating Co., at Norwich, Conn., based on my process of liquefying air by the refrigeration produced by expanding air in an insulated air-expansion engine, I find myself in possession of several hundred indicator cards taken from the engine during the time of experimentally testing it and perfecting the other air-liquefying apparatus erected in connection therewith.

Some of these cards will no doubt be of interest to mechanical engineers familiar with this branch of thermo-dynamics, or with refrigerating machinery generally, and I have therefore made a few selections for publication.


To interchanger and Liquefying Coils
600 lbs
Water Cooler.
Cal. Chloride Drying Drum.
Caustic Potash CO_2 Extractor.
Intake from street main, 90 lbs
Water Cooler.
CO_2 Auxiliary High-Pressure Air Freezing Drum (–30° F.)
CO_2 gas - 70 at. p.
CO_2 Condenser.
Liquid CO_2
CO_2 gas.
Return
To interchanger and engine.
Pre-cooling Drum for Closed-Circuit air (150 lbs) to be expanded in engine.
H.P. 70 ats. L.P. 12.5
CO_2 Compressor.
Return flow
Exhaust air from the engine. (atmospheric p)
Air Compressor. 150 lbs gauge.
Air Compressor. 90 lbs to 600 lbs gauge.

The N. E. Refrigerating Co.'s Air-liquefying Plant at Norwich, Conn., U.S.A.
(Place's Patent Expansion Engine System.)

FIGURE I.

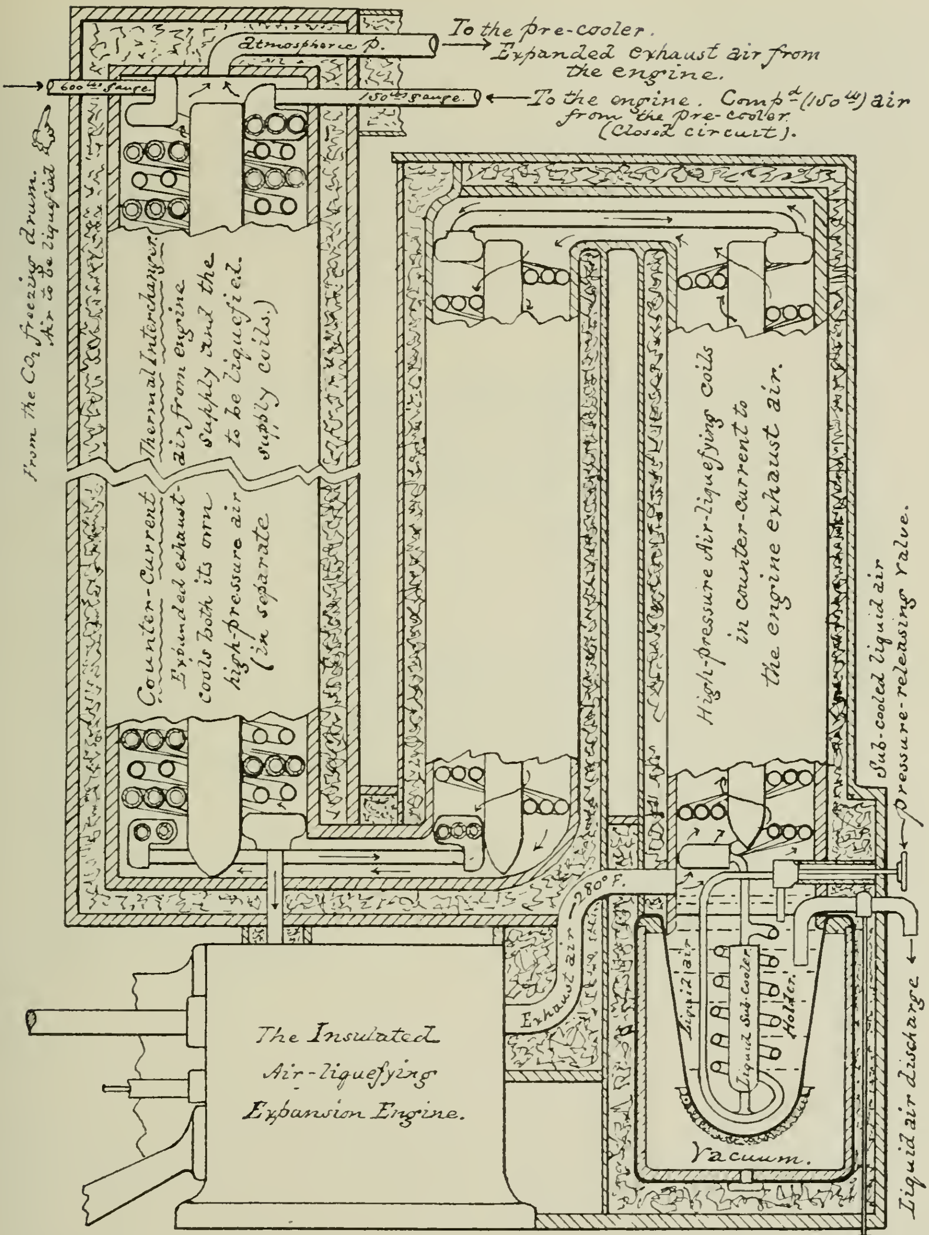
It would be well, perhaps, as a premise to the exhibition of these cards, to give a brief description of the engine and its accessory air-liquefying apparatus.

Besides the air-expansion engine, the plant (shown diagrammatically in Figs. 1 and 2) consists of an 8x8 inch air-compressor; moisture and carbonic acid extracting drums; a small CO_2 refrigerating system, comprising a 3 horse-power compressor, condenser and freezing air-drum; a high-pressure still-air liquefier, with submerged liquid-air sub-cooling tank; and a small high-pressure air compressor to supply the liquefier. The air in this case is taken from the street main of the Norwich Compressed Air Power Co., which is usually at 85 pounds, gage, and is run through a lime drum into the 8x8 inch air compressor, and compressed to between 160 pounds and 180 pounds, gage. This compressor is driven by a 9x9 inch upright engine, which is operated by compressed air from the street main. From the 8x8 inch compressor the compressed air of 160 to 180 pounds is conducted through cooling pipes laid in the Shetucket river close by, and is then passed, successively, through a calcium chloride drum and a caustic potash drum, and the freezing drum of the small CO_2 system; and thence into coils through a pre-cooling drum. It then enters the engine supply coils of the counter-current thermal interchanger, where it is cooled by the outflowing expanded exhaust air from the engine to a temperature of about —180° to —210°, and is then delivered to the valve chamber of the same air-expanding engine.

The cold, expanded exhaust air from the engine (at 260° to 300° Fahr. below zero), is conducted first over the high-pressure compressed-air liquefying coils, composing the still-air liquefier; and then over both these liquefying coils and the compressed-air engine supply pipes in a single conduit; and then over the engine supply pipes alone in the pre-cooling drum. From here it is discharged to the open atmosphere; and so complete is the transfer of heat in the system that this surplus air discharged to the open, is rarely more than a degree or so below the temperature of the water-cooled compressed air entering the engine supply coils of this pre-cooler.

The air for the liquefying coils is taken from the engine supply pipe, after water cooling, and is compressed to 42 atmospheres, and after being water-cooled is passed in pipes through the exhaust air cooling conduit to the liquefying coils. A compressor is being put in to take the air at atmospheric pressure and compress it to 85 pounds to supply the 8x8 compressor, and then, after the compressed air being supplied to the engine is thoroughly dry, the chemical drums and the CO_2 freezing drum will be cut out, and this air for the engine will be worked in a closed circuit; and the air supplied to the liquefying coils (at 600 pounds) will be passed through those drums before entering the interchanger, on its way to be liquefied.

The air-expanding engine is 6⅝x10 inch stroke, of the horizontal, double-acting reciprocating type. The cylinder is overhung, projecting from the frame which forms the cross-head slides, and is suspended on eight hollow tubes of fibre, which pass through two strong fibre slabs, 1¼ inch thick, which hold the cylinder heads against lead gasket packings firmly in place. Within these fibre tubes (or supporting hollow beams) are encased long insulated steel tie-bolts, ¾x40 inches, the whole being firmly drawn up against oak thimbles, 3 inches diameter (which enclose the fibre tubes), home against the face of the overhung cross-head frame. In this way the cylinder projects about 30 inches beyond the frame, and is not allowed contact with anything, so that no heat can be conducted to any of its parts to neutralize refrigeration. The whole cylinder is thoroughly insulated from the normal heat of the outside atmosphere, first by matched wood-lagging, made air-tight by shellac, then by a packing of eiderdown 4 to 5 inches thick, enclosed in canvas (made air-tight by shellac), and covered, including the ends, with nickel foil, which gives it all a highly polished surface; and outside of this a packing of 6 inches of fine washed wool, all around and over the ends, the whole being enclosed in shellac-treated canvas, and an outer matched-wood lagging, varnished; the piston-rod and main valve stem being enclosed in fibre sleeves about 18 inches long, which pass through the various insulations. These sleeves have brass-mounted fibre stuffing boxes on the outer ends, and both piston-rod and main valve rod are packed with dry braided flax and cup-leather packing. These stuffing boxes, although fully 16 inches from the cylinder, are always frost covered when the engine is running; but the rods run therein without lubrication, almost frictionless, and perfectly air-tight.


To the pre-cooler.
Expanded exhaust air from the engine.
Atmospheric p.
600 lbs gauge.
150 lbs gauge.
To the engine. Compd (150 lbs) air from the pre-cooler. (Closed circuit).
From the CO2 freezing drum. Air to be liquefied
Counter-Current Thermal Interchanger.
Expanded exhaust-air from engine
cools both its own supply and the
high-pressure air to be liquefied
(in separate supply coils.)
High-pressure Air-liquefying coils
in counter-current to
the engine exhaust air.
Sub-cooled liquid air
Pressure-releasing valve.
-280° F.
Exhaust air
Liquid air
Liquid Sub-Cooler
Holder.
Vacuum.
Liquid air discharge
The Insulated Air-liquefying Expansion Engine.

The Norwich (Conn) Air-liquefying Plant (Place Expansion Engine System). Diagram showing arrangement of the counter-current cooling coils, the engine, the liquefying coils, vacuum-jacketed liquid sub-cooler, &c.

FIGURE 2.

A NOVEL CUT-OFF.

The valve is of most novel construction—my own design, after many costly experiments. It is substantially a balanced Meyer variable cut-off, of the cylindrical piston type, exhausting over the outer ends. The cut-off valves (running inside the main valve) are arranged to cut off by the inner edge of each valve, thus insuring a much sharper cut-off than the ordinary type of Meyer valve; as when the air is cut off the main valve and cut-off valves are traveling in opposite directions, and at their greatest velocity. The main valve is given ⅜ inch air lap and $\frac{5}{16}$ inch exhaust lap, and set with a lead of 6 degrees. The travel of the valve is 2 inches for main valve and 1¾ inches for cut-off valve. The main valve eccentric is set 63 degrees in trail of the crank, and the cut-off valve eccentric 55 degrees in advance of the crank.

The cut-off valve stem is enclosed inside the main valve rod, both being of steel, of minimum cross-sectional area, and 50 inches and 30 inches long, respectively. The main valve rod is of course tubular, and is lined throughout with a bronze graphite-ring packed lining, forced in. The cylinder is of cast iron and has a seamless drawn steel lining, carefully machined and ground in place and highly polished; the main valve also runs in a similar lining. As the temperature of both cylinder and valve is from —200° F. to —310° F. all the time, of course no lubrication is used. After the trial of various metals and alloys, and many other substances, I found that leather and ordinary red paper fibre are the least affected by the extremely low temperatures I had to deal with. I found that friction of the piston or valves, at even these low temperatures, or leakage of either one, if allowed, would neutralize considerable of the refrigeration I sought; it was therefore absolutely essential to success that internal friction should be practically eliminated, and that both the piston and valves should run air-tight. After many experiments with iron, bronze, fibre, raw-hide and other ring packing, I finally adopted cup-leather packings, both for piston and main valve, and fibre-ring packing for the cut-off valves. They give no trouble—run, apparently, just as easily and smoothly, and are equally as effective at 310° below zero as at 60° above; and are absolutely air-tight at all times with an initial working pressure of 180

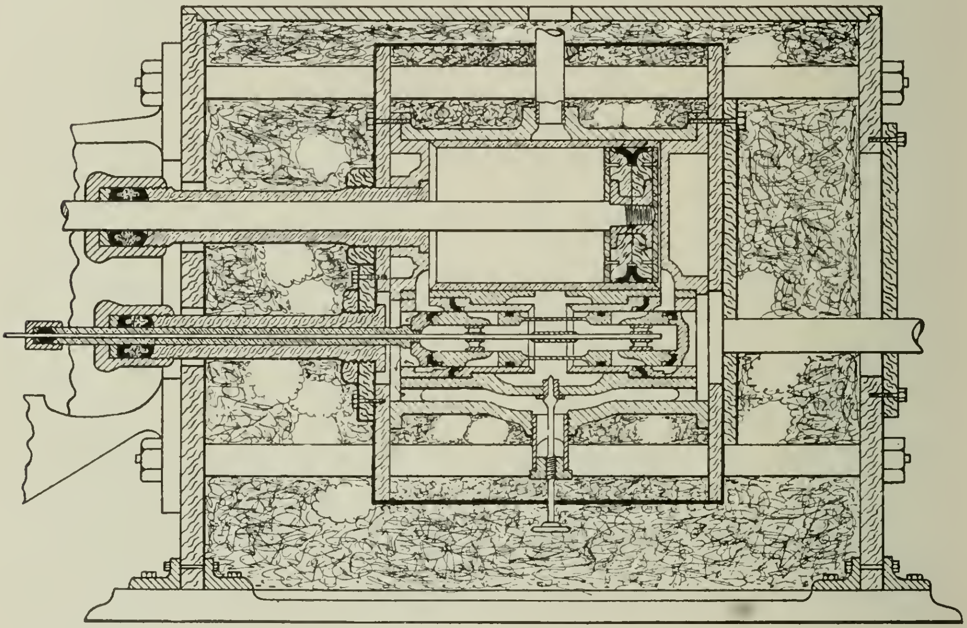


FIG. 3—INSULATED ENGINE CYLINDER OF PLACE'S AIR-LIQUIFYING EXPANSION ENGINE.

pounds gage. There is much less friction at these very low temperatures than there is at normal temperature.

The piston is of fibre (which runs with little or no friction on polished steel at low temperatures) held together by bronze collars, and made about .002 inch smaller in diameter than the inside diameter of cylinder. A disk cap of fibre on each side of the piston insulates the bronze collars from the air charge. This was found necessary to prevent loss by heat passing through the piston. The leather cups are in the centre, back to back, and held up to their work by a V-shaped bronze ring between them, make .004 inch smaller diameter than the cylinder bore, so as not to come in contact with the walls thereof. The leather cup packing practically takes the wear, and actually holds the piston in the centre of the bore, away from the cylinder walls on all sides. The sketch herewith (Fig. 3) shows the engine cylinder and valve in longitudinal vertical section.

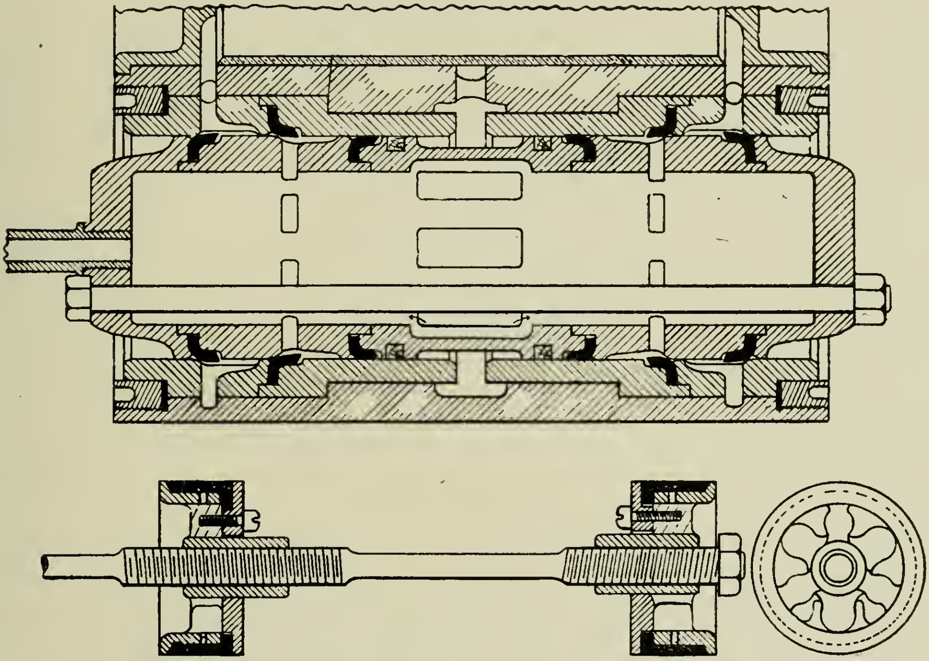


FIG. 4—THE PLACE BALANCED VARIABLE CUT-OFF AIR VALVE FOR WORK WITHOUT LUBRICATION.

The designing of the valve with cup-leather packing rings was a problem of extreme difficulty, on account of the annular ports in both valve and valve-chamber lining. The enlarged sketch (Fig. 4), however, shows how this was accomplished. The valve is made a very trifle smaller in diameter than the liner in which it operates, so that the wear is taken by the cup-leather packing; but great care had to be given to this point, otherwise there would be leakage immediately preceding admission and release.

Of course the exhaust air from the engine is carried back over the compressed air, being supplied to it for expansion therein. The liquefier is separate from and independent of the engine, and is supplied with air compressed to about 42 atmospheres, and all the air delivered to it is liquefied; whereas, the air supplied to the engine is compressed to not exceeding 180 pounds gage (often at not over 150 pounds). As stated, it is to be operated in a closed-circuit; that is, the same air is worked over and over—compressed, water-cooled, refrigerated in the pre-cooler and the counter-current thermal interchanger by the cold exhaust air from the engine, utilized after expansion to liquefy the high-pressure air in the liquefier coils first, and thence used to cool both the compressed air supplied to the liquefying coils and that of less compression being supplied to the engine; and then (after cooling the engine compressed-air supply alone) returned to the compressor to go through the same cycle again.

There are many details, a description of which would make this article too long. It is sufficient to say that the engine runs smoothly in all its parts, easier when it is using air at an initial temperature of —200° or —220° than when the initial temperature is normal, as at starting up. As the compressed air in the liquefying coils liquefies at its critical temperature, —220° F., and while at or above its critical pressure, it is not necessary to run the engine so that the exhaust will be below —240° to —280°. The air used in the engine is absolutely devoid of either moisture, carbonic acid gas, or anything else. It is pure nitrogen and pure oxygen; therefore, as there was nothing to freeze, I experienced no trouble whatever from frost or ice. The quick lime, calcium chloride and caustic potash drums are so constructed inside that the air is brought in direct contact with successive charges of these hygroscopic substances.

Three things which have been a source of difficulty, heretofore, in liquefying air, I succeeded in putting behind me from the start—moisture, carbonic acid gas, and insulation. The arrangements for elimination of the first two, and the design for securing the last, worked most satisfactorily—the pre-cooler, interchanger and CO_2 cooling drums all being thoroughly insulated with a mat of from 3 to 8 inches of wool, and covered with shellac-treated canvas.

The indicator cards here reproduced are on a scale of 80 pounds to the inch, the side to the right being the crank end in each case. Of the indicator diagrams shown, Nos. 1 and 2 are friction cards—the engine running free, without load. No. 3 is a card with load, soon after starting up, the initial temperature being normal, and the engine not having become cooled much below zero, the exhaust temperature varying, showing about 40° below, but constantly falling as the cold exhaust air cools the incoming supply of compressed air. In starting up the engine I usually started with 80 pounds to 100 pounds gage pressure, and gradually increased the compression, as the engine got cooled, to 160 pounds to 180 pounds; sometimes running on 150 pounds, and getting quite as good results therefrom as when the higher compression was used.

No. 4 card is almost ideal. There is a very slight throttling of the release on the head end after the piston has passed the dead centre, and there is, as shown, a trifle more clearance on the crank end than on the head.

This unequal clearance is corrected in card No. 5, and reduced a trifle at both ends.

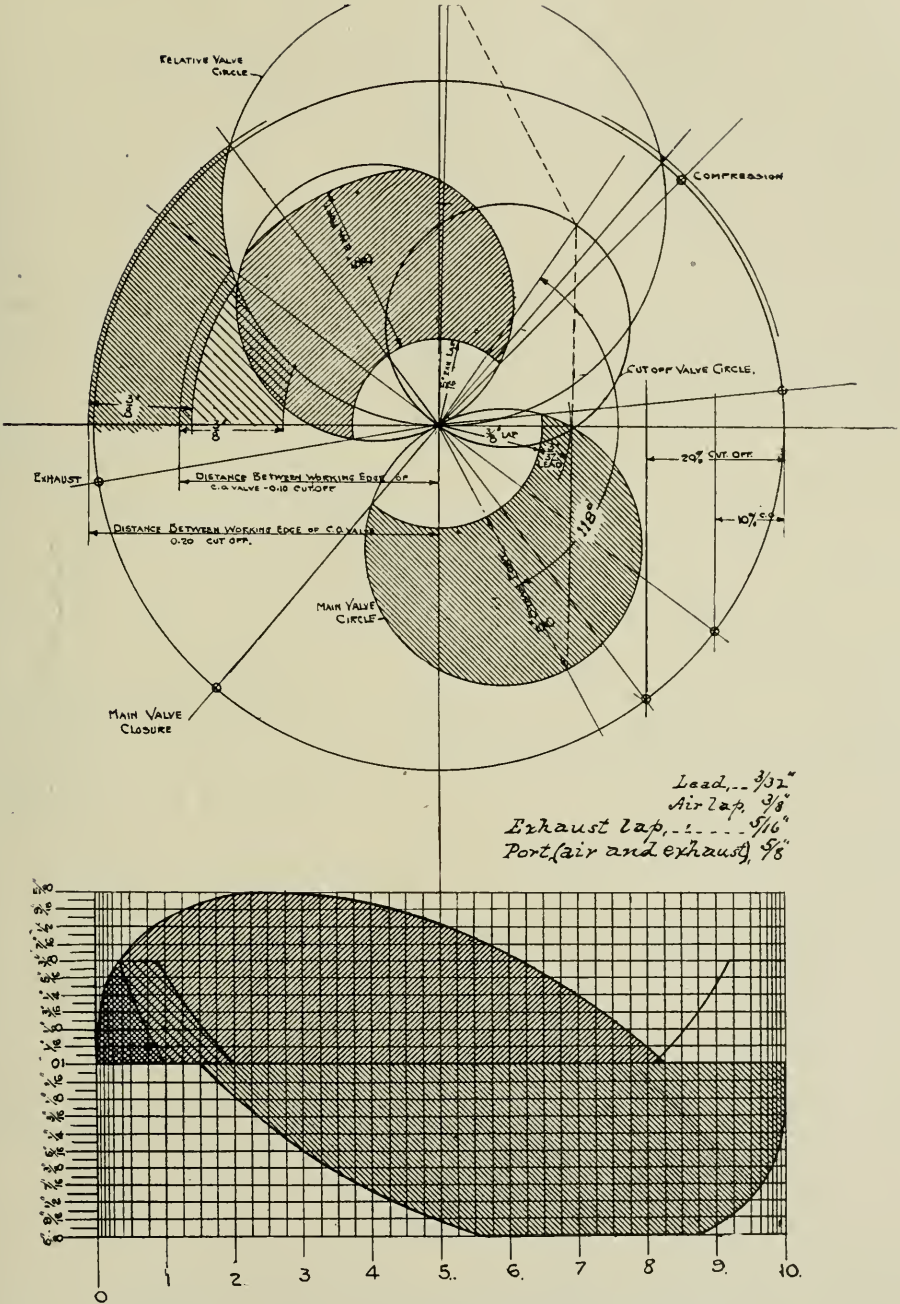
Cards Nos. 6 and 7 were taken a month apart, and some changes may have been made in the clearance and valve-setting; but the exhaust temperature was the same in each case, 200° below zero. Note the sharp cut-off in these cards.

In cards Nos. 8, 9 and 10 the expansion was not to atmosphere, their being about 10 pounds gage at release in Nos. 8 and 10. The back pressure in these, as well as in all of the cards, shows about 1½ pounds. These three cards were taken on three successive days, No. 10 being taken when running at considerably lower exhaust temperature than the others, or at —280° F.

Cards Nos. 11 and 12 were taken at still lower temperatures, or with the exhaust at 292° and 310° below zero, respectively. The initial cylinder pressure used when these cards were made was but 147½ pounds and 150 pounds gage, respectively.

Cards Nos. 8, 9, 10, 11 and 12 may all be regarded as vapor cards, as the air was exhausted in each at temperatures below the critical temperature of air. The temperature given on the cards was taken by a pentane thermometer in the exhaust conduit, just where it leaves the insulation surrounding the cylinder, about 16 inches from the valve; this exhaust conduit leads to the conduit enclosing the liquefier supply coils, and is of course heavily insulated with wool felt and fine washed wool.

I regard No. 12, when the engine was exhausting at a temperature of 310° below zero, as nearer a perfect expansion card than any of the others. The engine was then liquefying air in the cylinder, for the exhaust as it passes out over the ends of the valve is slightly raised in temperature. The compression (or cushioning of the piston) I purposely made as small as considered safe to run with, for compression neutralizes refrigeration. In this card (No. 12) there is just the least bit more compression on the crank than on the head end; otherwise the card is perfect. A trifle earlier



The Place Air-Valve.—Port-Opening Diagram.
10% and 20% Cut-off (6⅝" × 10").

FIGURE 5.

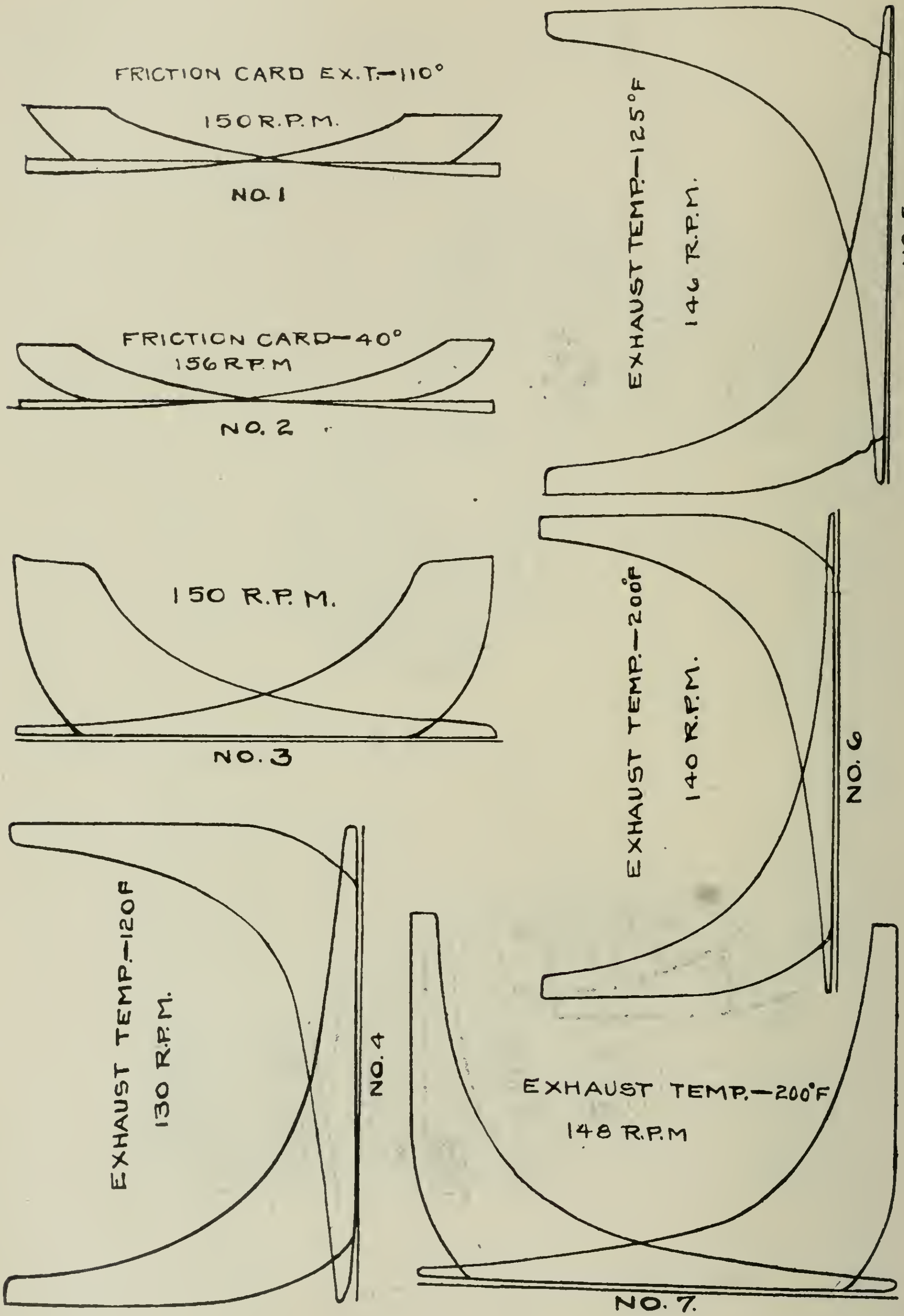

FRICTION CARD EX.T.—110°
150 R.P.M.
NO. 1
FRICTION CARD—40°
156 R.P.M
NO. 2
150 R.P.M.
NO. 3
EXHAUST TEMP.—120F
130 R.P.M.
NO. 4
EXHAUST TEMP.—125°F
146 R.P.M.
NO. 5
EXHAUST TEMP.—200°F
140 R.P.M.
NO. 6
EXHAUST TEMP.—200°F
148 R.P.M
NO. 7.

FIGURE 6.

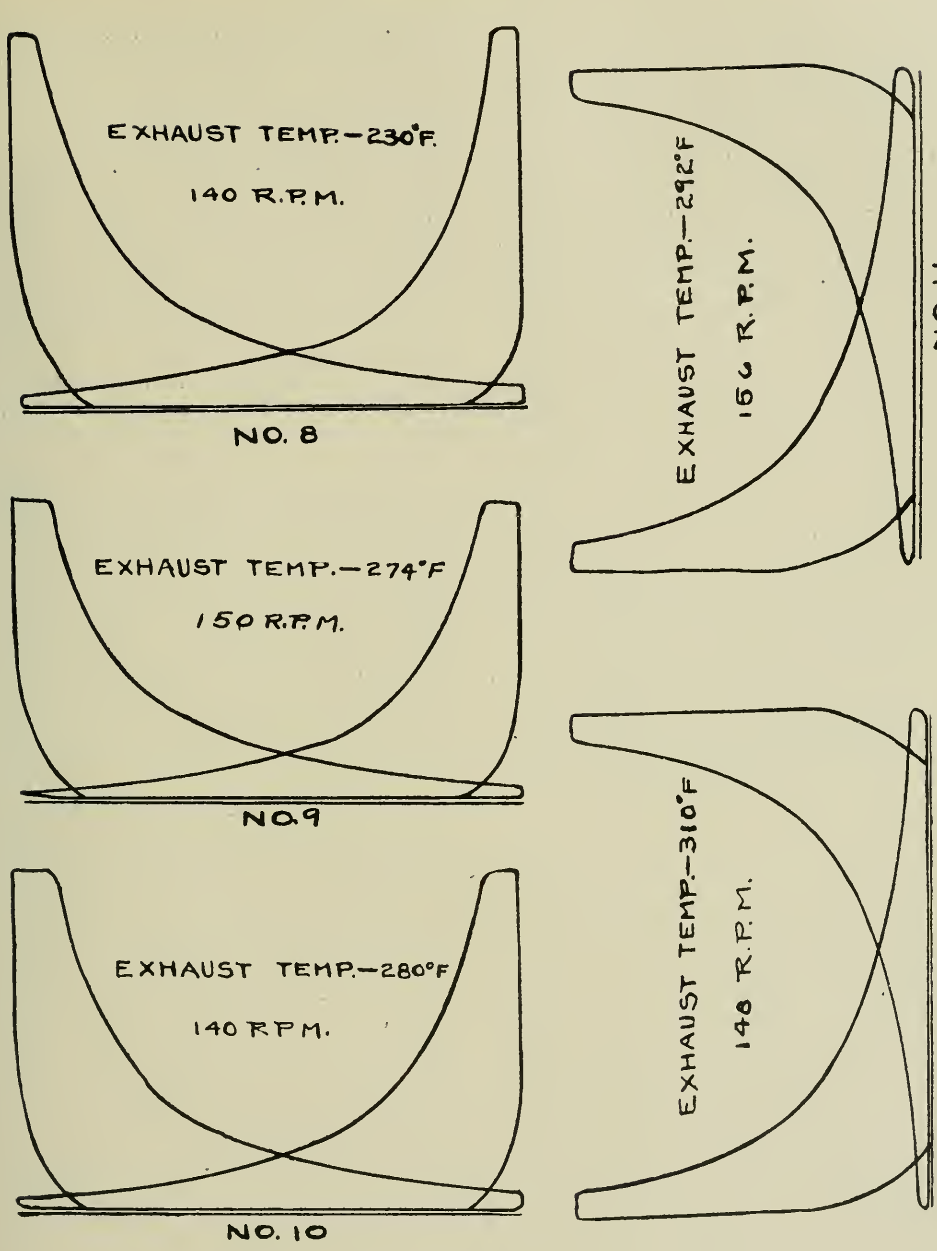


FIGURE 7.

cut-off could have been used, so as to have carried the expansion down to atmosphere. Analyzing this card (12) I find the actual cut-off was 5 per cent., the piston displacement being 344.7 cubic inches, and the clearance (including indicator pipes) was 26.5 cubic inches. Therefore, the initial volume expanded was 344.7″ × .05 + 26.5″ = 43.7 cubic inches, at 150 pounds gage; and the volume or space it was expanded into was 344.7″ + 26.5 = 371.2 cubic inches; so that it was working with an actual expansion of about one volume into 8.5 volumes, or the equivalent of about 11.8 per cent. net cut-off; and yet it was expanding the air from 150 pounds gage to about 21 pounds absolute.

With compressed air at 175 pounds gage and the initial temperature 60° F., the theoretical fall in temperature in expanding the air to atmosphere, is to 213° below zero; the expansion to atmosphere from an initial temperature of —180°, gives theoretically a terminal temperature below that of condensation, even with no greater initial cylinder pressure than 150 pounds gage. The air in expanding, however, absorbs heat from the cylinder and all its parts, so that at first the terminal temperature is very considerably above the theoretical result; but as the cold exhaust air continues to reduce the temperature of the incoming compressed air supplied to the engine, the exhaust air grows uniformly colder and colder until partial liquefaction is reached in the cylinder, (—312.6°).

I had no means of taking accurately the temperature of the compressed air in the valve chamber, or the initial cylinder temperature before expansion; but when card No. 12 was taken this initial temperature, I have no doubt, was —180° or lower; and the result of any lower initial cylinder temperature than —180° with 150 pounds gage expanding to atmosphere, would simply be increased cylinder condensation, without any change in the terminal temperature.

The ratio of density between air at 60° F. and air at —200°, the pressure being constant, is about 2; therefore in theory it takes 2 cubic feet of the compressed air delivered from the compressor water-cooler, to make 1 cubic foot of the same compressed air in the valve chamber, when the temperature there is —200°. The air as exhausted from the cylinder when card No. 12 was made, before passing over the liquefier coils, was in theory considerably less than one-third the volume of free air—notwithstanding it was at substantially atmospheric pressure.

The engine is made to do work on the counter-shaft which drives the high-pressure compressor; and as near as I can judge, we recover from it ordinarily about 22½ per cent of the power required to compress the air it uses (possibly not over 20 per cent.), varying with the initial temperature of the compressed air expanded in the engine. This initial temperature rises or falls according to the amount of liquid drawn from the liquefier, or the frequency with which it is drawn therefrom; or according to the amount of heat allowed to be absorbed by the expanded exhaust air before it is delivered to the interchanger to cool the incoming compressed air being supplied to the engine.

The advantage of a separate liquefier and using therein air compressed to 600 pounds is, that all of the air is liquefied (without reduction of pressure) at its critical point—or at its critical temperature (—220°) and at or above its critical pressure (39 atmospheres), when its density as a gas is identical with its density as a liquid; and, therefore, there is no latent heat of condensation given out to retard liquefaction, as there is practically no further contraction of volume involved in its change of state.

The high-pressure liquefying coils deliver the liquefied air by gravity to a high-pressure liquid receiver; and the liquefied air as released from pressure and drawn from this high-pressure receiver is delivered to a vacuum-jacketed container or low-pressure holder which surrounds the receiver; so that this liquid receiver is practically a sub-cooling tank, as it is kept submerged in liquid air of atmospheric pressure, the surplus or overflow liquid from the holder only being drawn from the system.

By this method of liquefying air when at its critical pressure, by utilizing the cold exhaust air from the air-expansion engine to cool such high-pressure air down to its critical temperature, and then delivering it as liquefied (without reduction of pressure) to a cooling tank or receiver submerged in liquid air of atmospheric pressure, the newly liquefied air in the submerged receiver is sub-cooled after liquefaction, from —220° to —313°, so that there is practically no loss by vaporization on being released from pressure; and the released liquid as it evaporates (or that portion which is evaporated after release in sub-cooling the liquefied air which has taken its place in the submerged high-pressure receiver) requires the maximum of latent heat of vaporization (or about 120 B t u per pound) to evaporate, all of which must be taken from the liquid air in the submerged receiver, or from the liquid itself as released. Besides, all vapors from the low-pressure liquid holder are utilized to cool the air to be liquefied, as all such are conducted back over the incoming supply of compressed air, being mixed in the out-flowing expanded air conduit with the exhaust air from the engine. *The resultant product of liquid air drawn from the system is about 7½ pounds per h.p.h. of energy expended.* Greater economy may be expected as the machinery gets worn down to its work.

This article would be incomplete without due acknowledgment of the untiring efforts and constant work of Mr. John A. Inslee, President of the New England Refrigerating Co., during the past three years, in financing the company and otherwise aiding in bringing the enterprise to final success.

Glen Ridge, N. J., February 22, 1908.

A LIQUID AIR RESCUE APPARATUS

A device employing liquid air for rescue apparatus to be used in coal mines and elsewhere when the air is unbreathable has been invented by Mr. Otto Simanis, Norfolk House, Strand, London, and the London correspondent of the *Scientific American* has forwarded a description. The "Aerolith," as it is called, comprises a bag, containing the liquid air absorbing medium, which is strapped to the wearer's back like a knapsack. The apparatus weighs only 24 pounds when fully charged. From the top of the knapsack extends a flexible tube connecting an upper section of the chamber containing the absorbed liquid air with the mouth, there being a mask fitted over the entire face with mica glazed apertures for the eyes, or simply a mask inclosing the eyes and mouth. This flexible coupling is connected by another short length of flexible tube, the connection being made about 6 inches below the mouth to the liquid air container at the opposite upper section.

The most essential part of the apparatus is the compartment containing the liquid air. This is filled with asbestos wool, which the inventor has discovered to be the best of all absorbing substances, while at the same time it enables evaporation to be automatically controlled. This absorbent is thoroughly regulated by special means, so that not only is evaporation from external heat avoided when the apparatus is not in operation, but, when evaporation is in progress, to effect it so gradually as to be just sufficient for the needs of the wearer's lungs. Attached to the apparatus and lying flat against its outer surface is a second bag, through which escapes exhaled air from the lungs.

The wearer clamps the mask carrying the mouthpiece from the liquid air chamber to his mouth, and commences to breathe in a normal manner. The warm expired air from the lungs passes through the tube, and enters the chamber containing the absorbed charge of liquid air. This at once causes the evaporation of a small quantity of liquid air of the same volume as would be exhaled by a man under ordinary circumstances. This evaporated charge passes up the second tube, and by the next inhalation is drawn into the wearer's lungs. This cycle of operations is repeated, the warm expired breath evaporating charges of fresh air until the supply has become exhausted. The atmosphere evaporated from the absorbing material is cool, fresh and pure, the intensely cold vaporized air being warmed by its passing through the tube, so that by the time it reaches the mouth it can be inhaled without the slightest discomfort. The expired air, after passing over the absorbing medium and releasing the requisite quantity of fresh air in its passage, finally escapes into the outer atmosphere.

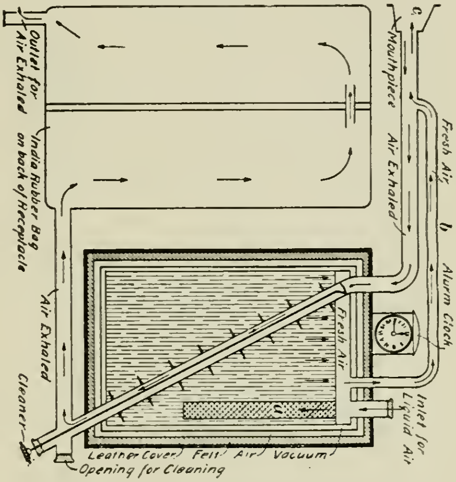


DIAGRAM OF AEROLITH APPARATUS.

The liquid-air absorbent reservoir is charged from a supply carried in a small receptacle, the liquid air being stored in a spherical vacuum vessel of the type evolved by Professor Dewar. This reservoir is well insulated, the loss from evaporation being very small. It is made of varying capacities according to requirements, the average capacity ranging from 0.7926 to 1.5852 gallons. As air in its liquefied state is compressed into one eight-hundredth part of its normal volume, 1.32 gallons of liquid air evaporate into about 244,080 cubic inches of pure air at atmospheric pressure; this quantity is sufficient for about three hours' use.

In connection with the evolution of the "Aerolith" apparatus, the inventor has also devised a cheaper method of producing liquefied air. With the apparatus he has designed the cost of production is approximately 18 cents per gallon, but by the aid of some recent modifications it is anticipated that the cost will be reduced to 5 cents per gallon. In the case of large coal-mining areas, such as those existing in the north of England, Westphalia and Pennsylvania, it would be more economical to erect one central generating station to serve a large number of mines. A plant with an 8 horse-power engine and capable of producing one gallon of liquid air per hour, can be erected for about $2,000.

[It will be noted that the preceding article promises to produce liquid air more cheaply than this.]

COAL STORAGE OF HEAT AND ENERGY

A pound of coal represents five times as much energy as a pound of the strongest explosive known, blasting gelatine. My friend had overlooked the fact that a pound of dynamite, though it gives out nearly 150,000,000 H. P., does so only for the space of 1-50,000 of a second. He had omitted to take into account the element of time, and had confused power in the ordinary sense with energy, which is the capacity for doing work.

A similar confusion is sometimes made between energy and the creation of high temperatures. This can be very well illustrated by the use recently made of a finely-powdered aluminum, both as a component of explosives and as an agent for producing very high temperatures, in the shape of Dr. Goldschmidt's "thermit." In both cases the fact is utilized that aluminum is easily, and in the shape of fine powder, almost instantaneously, converted into its oxide, alumina, by substances capable of giving off oxygen. In the case of thermit, a mixture of finely-powdered aluminum and ferric oxide is, when lighted, decomposed instantaneously into molten iron and aluminum oxide. The heat produced thereby far exceeds that produced by coal in any conceivable way; it is equal to that of the electric arc. One of the most important applications of this agent occurs in the welding of the ends of railway rails, when already laid down, into one continuous rail of any length required. And yet the total energy of thermit is only 450 thermal units per kilogram, or in other words, about one-twentieth of that of the best coal. But, whereas, it takes a good deal of time to burn a pound of coal, during which process there is a great loss of heat by radiation, and the heat is spread over a current of gases which we call the flame, a pound of thermit burns off in about one second, and, as there are no gaseous products formed, all the heat generated remains within the molten iron and alumina, which accounts for the extreme degree of heat to which these are brought.—*Prof. George Lunge, Royal Institution.*

AIR LIFT AGITATION IN CYANIDING

That fine grinding of most of the ores to be treated by the Cyanide Process is beneficial is generally admitted. The quartzose envelope of the metallic particles has to be broken in order to allow contact with the dissolving medium and so, departing from former practice, it has more and more become the endeavor of metallurgists to "slime" all the ore and, abandoning the separation of the real slimes from the fine sands, agitating both together. Mechanical stirrers assisted by centrifugal pumps were used with some success, but it was found that the presence of even fine sands made the operation uncertain, and costly.

An improved method of agitating mixtures of slimes and sands has been invented by Mr. F. C. Brown, manager of the Komata Reef Gold Mines in New Zealand and introduced by him on several important works in that country with remarkable success. Compressed air is used for this purpose, applied in a peculiar manner in tanks of which the accompanying cut is a sectional elevation. The tanks are cylindrical in appearance but consist internally of a cylindrical part terminating in a cone with a 60 degree slope. The weight of the tanks and contents is transmitted by the continuation of the cylindrical shell, stiffened by vertical angle bars, to a double angle iron resting upon a solid foundation. The lower end of the cone is closed by a cast iron bottom. A doorway in the lower part of the shell gives access to the space around the cone and a manhole in the latter facilitates inspection of the valves, etc., when the tank is empty. The discharge of the contents, after agitation, takes place through a pipe near the bottom, provided with a valve, cock or plug.

The internal fittings of the tank consist of:

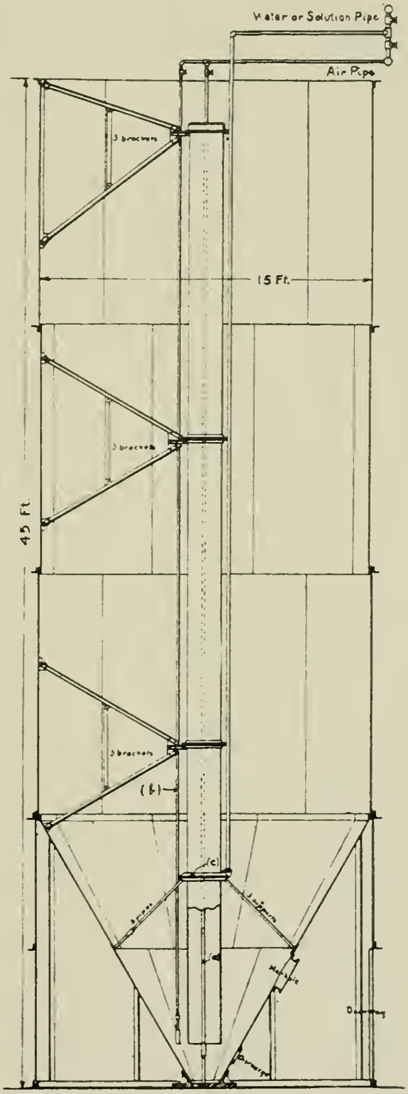
1. A central tube called the air lift, of a diameter of about one-twelfth of that of the tank. It is open at both ends and extends from about 18 inches above the charging level to the same distance from the lowest point of the cone. It is supported by means of brackets as shown in the drawing, there being three of them in each set.

2. An air pipe (a) in the center of the lift, closed below and resting on the bottom of the tank, has at the level of the inlet of the air lift a "sleeve" valve which prevents the pulp entering and allows the air to escape in an upward direction when the air-pressure exceeds that due to the head of pulp in the tank.

3. A second air pipe (b) outside the lift which serves to keep the pulp in gentle motion while filling or emptying the tank when the submergence is insufficient to allow the air lift to work.

4. An apparatus consisting of an annular casting (c) surrounding the air lift, supported on the sides of the cone and provided with a number of pipes having sleeve valves discharging against the cone, the apparatus being connected to the air, and water or solution pipes. This arrangement is sometimes useful when discharging to wash down the sands which may have settled on the cone after the agitation is stopped.

The mode of operation, like the apparatus, is very simple. The tank being filled with ground ore and solution, air is admitted through pipe (a), which, mixing with the contents of the lift, lightens the column inside and causes it to overflow, while fresh pulp runs in at the bottom and is in turn brought to the top, thus producing a perfect circulation which is kept up as long as the supply of air lasts. The initial air pressure has to exceed that of the column in the air lift, but when once circulation has been established the pressure can be considerably reduced. At first also a greater quantity of air is required in order to obtain a sufficient velocity of circulation to remove all the pulp which may have packed on the cone during the period of filling. To commence operations 50 pounds of air pressure are used, but when the cone is clear of sand, the half of this pressure is sufficient. The quantity of free air consumed depends upon the proportion of slimes and sands, the degree of grinding and the viscosity of the pulp. In most cases 100 cubic feet of free air per minute will keep the mass in lively motion and prevent the settling of sands on the cone. Large tanks loaded with slimes only are agitated in N. Z.



PACHUCA AGITATING TANK.

with an expenditure of less than one horsepower. For a plant treating 100 tons per day of mixed sands and slimes a 10-horse-power compressor is sufficient.

The agitation by these means is perfect, and very efficient aeration of the mass is obtained at the same time. Even after weeks of rest, when the contents of the tank have packed to a hard mass in the cone, agitation can be readily started and after about one hour the mass is in perfect circulation. Sands can be treated as readily as slimes and as they fall through the solution more rapidly than the slimes they receive a more energetic treatment. It is clear that the dissolving action of the cyanide solution is much more rapid than when less perfect modes of agitation and aeration are used. In fact, 24 hours' treatment are generally sufficient, and extractions of 92 per cent. of the silver and nearly all the gold have been obtained in that time.

The first cost of a plant of this description is much less then when mechanical agitation of the ordinary kind is used and the treatment charges are also considerably reduced. One man can do all the work connected with the agitation of a 100-ton plant. There is no danger of anything getting out of order and no chance of the contents settling down.

The above description we take from the *Mexican Mining Journal,* which says further: The system was introduced into this country by Mr. A. Grothe in the Hacienda de San Francisco at Pachuca and results there obtained induced the San Rafael and La Union Companies at Pachuca to put in 200 and 100-ton plants respectively. A 50-ton installation is under way at the Natividad Company's mill in Oaxaca, while the Veta Colorado Mining & Smelting Co., of Parral, is building an experimental plant of two tanks of 15 feet diameter and 45 feet high.

A power contract has been made by the city of New York with the New York Edison Company for current for operating the electric pumps for the new emergency high pressure fire mains. *A penalty of* $500 *per minute* is imposed for delay of the electric power supply beyond three minutes after a fire alarm.

The wettest place on earth is reputed to be Cherrapunji, India. and a recent fall of 74½ inches of rain in five consecutive days must discourage other competitors for the record.

EFFICIENCY TESTS OF AIR LIFTS AT SOUTH AFRICAN MINES

The two 200-stamp mills erected, about a year ago by the East Rand Proprietary Mines, Limited, on the properties of the Cason and Angelo Companies have several features of interest, not the least important of which are the air lifts used for raising the sands and slimes pulps to the settling tanks. The air lifts in the above plants replace the ordinary tailings wheel, or the less frequently used tailings pump, and, as these are the only two plants on any of the Witwatersrand mines in which an installation of air lifts is entirely relied upon for lifting pulp, their operation has been watched with a considerable amount of interest by local engineers.

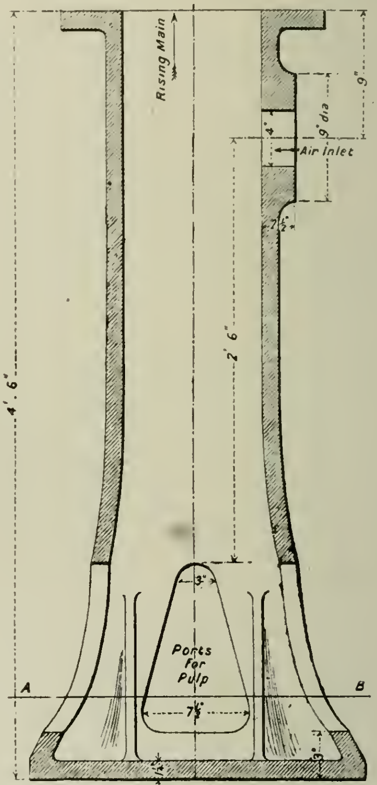


FIG. I.—FIRST FOOT PIECE.

An air lift pump consists of (1) a foot piece provided with ports for the admission of the liquid to be lifted and a compressed air inlet, and (2) a rising main. The foot piece is sunk to a distance below the level of the liquid to be raised proportionate to the head to be lifted against, and compressed air is admitted at the air inlet, the initial air pressure necessary being dependent upon the pressure in the well or sump at the point of air admission to the foot piece.

The operation of the "lift" is dependent upon the aeration of the column of liquid contained in the rising main, and not upon an ejector action, as is erroneously imagined by many engineers. The maximum efficiency of a given "lift" is therefore attained when the head to be lifted against, the proportion of submersion to head, and the pressure of the compressed air at the air inlet are in correct ratios. If the air pressure is too high the amount of work performed in attaining the excess pressure is lost. If the degree of submersion is too great in proportion to the head, then it is necessary to raise the air pressure higher than is economical in order to deliver it into the foot piece against the increased liquid pressure due to the excess submersion, with a resultant loss of efficiency. On the other hand, if the proportion of submersion to lift is not great enough there is not sufficient aeration of the column of liquid to give the requisite velocity to the column without the use of an unduly large volume of compressed air—as expressed in its equivalent amount of free air—per cubic foot of liquid lifted, this again resulting in a loss of efficiency if the power requisite to compress the larger volume of free air to the lower pressure required is greater than that necessary to compress the smaller quantity to a higher pressure.

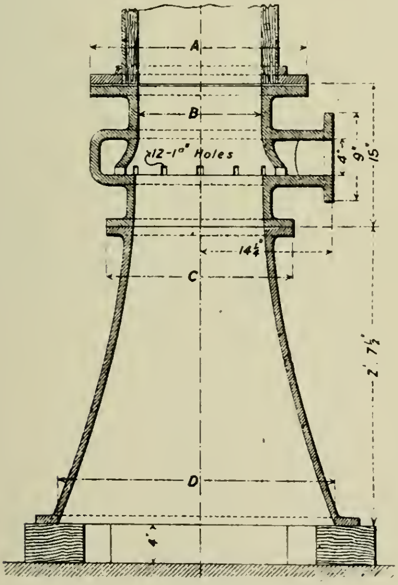


FIG. 2—IMPROVED FOOT PIECE.

In the absence of trustworthy data upon which to base calculations for the Angelo and Cason plants, it was essential that a series of tests should be carried out to ascertain the most economical ratios of the three determining factors. These tests, the results of which are tabulated below, were carried out by Mr. R. Henderson, the construction engineer of the East Rand Proprietary Mines, Limited, under the direction of the company's consulting engineer, Mr. N. Wilson.

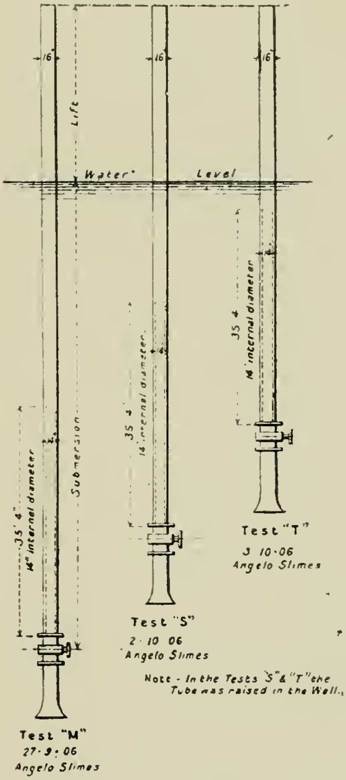
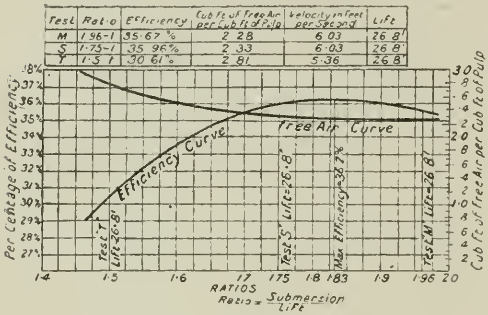


FIG. 3.—POSITION OF TUBES IN WELL.

The "lifts" are, in both the Angelo and Cason plants, arranged in groups for sands and slimes, respectively. Each tube is placed in a separate well or sump, which for a few feet at the top is extended in area so that variation in the quantity of liquid flowing to the well may not cause too rapid fluctuations in the level. By this arrangement the tube can be fixed in a well very little larger than its own diameter, and yet the level of the liquid can be kept practically constant. A float which, as it rises and falls with the level of the liquid, rotates a small plug valve regulates the supply of compressed air to the tube, and provides for irregularities in the flow to the well. The design of the foot piece originally experimented with is shown in Fig. 1. Four ports at the lower end, which is belled out, provide for the admission of the pulp, whilst through a 4-inch hole, placed 2 feet 6 inches above the top of the ports, compressed air is admitted. This design was found to be very inefficient, and later tubes were fitted with the type shown in Fig. 2, which is belled out at the lower end to a greater extent than in the original type—so as gradually to accelerate the velocity of the liquid—and the bottom is open, the foot piece resting on four timber supports. An air belt is provided 3 feet 3 inches above the bottom of the foot piece, this belt delivering air to the tube through a ring of twelve holes, each 1 inch square. This design gave vastly improved results. The dimensions at A, B, C and D for the foot pieces of the various tubes were:



Test	Ratio	Efficiency	Cub ft of Free Air per Cub ft of Pulp	Velocity in Feet per Second	Lift
M	1 96-1	35·67 %	2 28	6 03	26 8'
S	1·75-1	35 96%	2 33	6·03	26 8'
T	1·5 1	30 61%	2 81	5·36	26 8'

FIG. 4.—EFFECT OF VARYING RATIOS.

Dimensions of foot piece. A in.	B in.	C in.	D in.	Where used.	Tests.
21	11½	19	22 ..	Angelo Slimes and Cason Sands	.. E.I.J.K.L. .. No. 1.
23	13½	20	30 ..	Angelo Slimes and Cason Slimes	.. D.M.S.T.N.O.P.Q.R. .. No. 2.

The rising main used was mild steel tubing. expanded into cast steel flanges. The lengths of main were made uniform so as to be interchangeable. The mains used with the foot pieces having 11½ inches diameter throats were 14 inches internal diameter, whilst those with foot pieces having 13½ inches diameter throats were 16 inches internal diameter. The lower portions of the rising mains were in each instance reduced 2 inches in diameter by a lining of timber 1 inch thick. This lining serves a double purpose, as it protects the lower lengths of main from damage by abrasion—the sands to a greater and the slimes to a lesser degree exercise a cutting action in their flow—and also, by restricting the area in the lower length tends somewhat to equalize the velocity of flow in the length of the main. The air bubbles, by expanding as they rise and decrease in pressure, increase the velocity of flow of the aerated liquid as it rises, if the main is of uniform diameter throughout. A main of gradually increasing (or tapered) diameter would be necessary to provide an absolutely uniform velocity throughout its vertical length, and this would, of course, be commercially impossible to provide. The general arrangement of the "lift" and well is shown in Fig. 5.

In carrying out the experiments at the Angelo Slimes plant, a series of seventeen tests were made, as shown in Tables I. to V., the following being the method employed in obtaining the various data.

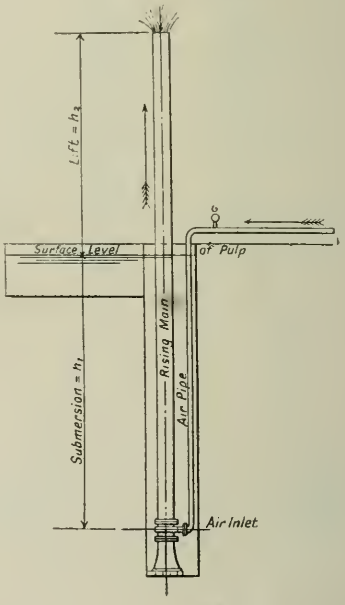


FIG. 5.—GENERAL ARRANGEMENT OF AIR LIFT.

Air measurement.—A special air compressor was used for the purpose of working the air lifts. The compressor was run at such a speed as to keep the level of the slimes in the well of the "lift" constant. The revolutions of the compressor were then noted and kept constant during the test. Then, knowing the revolutions and the piston displacement of the air compressor, the consumption of free air per revolution or per minute could be obtained.

Slimes.—"Slimes" means a mixture of water and the very fine or "slimy" portion of the crushed ore coming from the reduction plant.

Slimes measurement.—When everything was running steadily, the slimes to be dealt with was measured in a 50 feet diameter tank; the flow in cubic feet per minute thus being obtained.

Specific gravity of slimes.—A number of samples of the slimes were taken and the specific gravity obtained, an average of the results being taken.

Theoretical H. P. in lifting slimes a height $=h_2$.—The specific gravity used for determining the theoretical H. P. was taken as 1.1013, or 63.3 pounds per cubic foot of slimes.

Adiabatic compression $P_1 V_1{}^{1.408} = P_2 V_2{}^{1.408}$

$$\text{M.E.P.} = 3{\cdot}45 \left\{ P_2 \left(\frac{P_1}{P_2}\right)^{\cdot 71} - P_1 \right\}$$

i = H.P. per cubic foot of free air

$$= {\cdot}015042 \left\{ P_2 \left(\frac{P_1}{P_2}\right)^{\cdot 71} - P_1 \right\}$$

$$\text{Efficiency per cent.} = \frac{\text{Theoretical H.P.}}{\text{Air H.P.}} \times 100$$

Index of Symbols used in Calculations:—

h_1 = Depth of submersion in feet.
h_2 = Height of lift in feet.
V = Velocity in feet per second of the pulp through the throat.
Q = Quantity of pulp in cubic feet per minute.
C = Constant for theoretical H.P. $= \frac{63{\cdot}3}{33{,}000} = {\cdot}001918$.
G = Gage showing working pressure of air (see Fig. 5).
i = H.P. per cubic foot of free air compressed t P_2.
M.E.P. = Mean of effective pressure.
P_1 = Atmospheric pressure (absolute) = 12·5 lb. per square inch.
P_2 = Working pressure at the air lift (absolute).
A = Cubic feet of free air per minute.
a = Area of throat of the foot piece of rising main in square feet.
P = Working pressure at the air lift (gage).

	Test.	B.	C.	D.	E.
Conditions.	Date ...	11-7-06	11-7-06	16-7-06	16-8-06
	Tube ...	East and West	East and West	East	West
	Number and size of tubes used ...	Two 10in.	Two 10in.	One 14 to 16in.	One 12 to 14in.
	Submersion, in feet ...	32 75	35·75	37·75	48·85
	Lift, in feet ...	32·5	29·5	27·5	27·09
	Ratio submersion to lift ...	1·009 to 1	1·21 to 1	1·372 to 1	1·77 to 1
	Working gauge pressure, in lb. per square inch ...	15	16	17	22
	Average number of stamps running ...	155	157·5	145	160
	Kind of foot piece ...	Fig. 1	Fig. 1	Large, Fig. 2	Small, Fig. 2
	Throat diameter of foot piece ...	10in.	10in.	13½in.	11½in.
Performance.	Free air per minute, in cubic feet ...	2256	1279	796·48	846
	Free air per minute per stamp, in cubic feet ...	14·5	8·12	5·49	5·28
	Free air per cubic foot of slimes, in cubic feet ...	7·27	4·06	2·74	2·64
	Cubic feet of slimes per minute ...	310	315	290	320
	Cubic feet of slimes per stamp per minute ...	2·0	2·0	2·0	2·0
	Throat velocity, in cubic feet per second ...	4·7	4·8	4·855	7·39
	Theoretical horse-power ...	19·3	17·8	15·23	16·6
	Horse-power per cubic foot of free air compressed ...	·048	·050	·053	·064
	Air horse-power ...	108·72	64·74	42·21	54·144
	Efficiency, per cent. ...	17·7	27·5	36·15	30·55

TABLE I.—AIR LIFT AT ANGELO SLIMES PLANT.

Theoretical H. P.

$$= \frac{\text{Quantity of pulp in cub. ft. per min.} \times 63{\cdot}3 \times \text{lift in ft.}}{33{,}000}$$

$$= \frac{Q \times 63{\cdot}3 \times h_2}{33{,}000}$$

$$= C \times Q \times h_2$$

$$= {\cdot}001918 \times Q \times h_2.$$

Air H. P.—This was obtained by multiplying the cubic feet of free air per minute by the value of the H. P. required to compress one cubic foot of free air to the working air pressure, as shown in this case on the gage G, Fig. 5. In these tests it has been assumed that the compression is adiabatic, and therefore taken under worst conditions.

REMARKS ON TESTS.

Table I. *Tests B, C, D and E.*—It will be noticed that these tests, taken in the above order, have increasing depths of submersion and decreasing heights of lift, the ratio $\frac{\text{Submersion}}{\text{Lift}}$ varying from 1.009 to 1 to 1.77 to 1. *Tests B and C* were each run with two 10-inch tubes. The cubic feet of free air used to one of slimes being 7.27 and 4.06 cubic feet respectively, the latter being with the greater depth of submersion. The efficiency was 17.7 per cent. and 27.5 per cent. respectively. The original type of foot piece was used. See Fig. 1.

In Test D a 14-inch widening to 16-inch diameter tube was used.

The ratio $\frac{\text{Submersion}}{\text{Lift}}$ was increased to 1·372 to 1.

The ratio of cubic feet of free air to cubic feet of slimes lifted in this case was reduced to 2·74 to 1. the efficiency being increased to 36·15 per cent.

The new type of foot piece was used in this test, with a throat diameter of 13½ inches. See Fig. 2.

Test E.—A 12-inch widening to 14-inch diameter tube was used.

The ratio $\frac{\text{Submersion}}{\text{Lift}}$ being increased 1·77 to 1. The consumption of free air per cubic foot of slimes lifted was further reduced to 2·64 to 1.

It will be noticed that in this test the submersion was considerably greater than in Tests B, C and D. This increased submersion necessitated the increase of the working air pressure from 15 pounds to 22 pounds. Pressure being an important factor in obtaining the air horse-power accounts for the decrease in the efficiency to 30.55 per cent. as compared with Test D. The foot piece used in this case was the same type as in Test D, but with 11½ inches throat diameter.

Summary, Table I.—These tests can, under the circumstances, hardly be taken as comparative, but more as progressive, for in each test the conditions were altered.

The ratio $\frac{\text{Submersion}}{\text{Lift}}$ suggests that there is a point where, under certain conditions, a maximum efficiency can be obtained. However, later tests show this more clearly. Another detail shown to be of importance is the throat velocity.

Table II. Tests I and M.—These two tests were carried out on the same day. Test I: a 12 inch widening to a 14 inch diameter tube, and in Test M a 14 inch widening to a 16 inch diameter tube being used. The ratio of submersion to lift being 1.8 to 1 and 1.96 to 1 respectively. Test M shows a decreased consumption of air per cubic foot of slimes and an increased efficiency as compared with Test I, the better performance being obtained with the smaller throat velocity. The increased efficiency is very small, but would no doubt have been greater with a ratio of submersion somewhere about the same as Test I.

Table III. Tests M, S and T.—In these tests it will be noticed that the ratio of submersion to lift is varied from 1.96 to 1 to 1.5 to 1; the lift being kept constant. In tests S and T the tube was raised in the well to alter the submersion—see Fig. 3, which illustrates this. The size of the tube used in each test was the same, viz., one 14 inches widening to 16 inches diameter with the same size, and the new type of foot piece with 13½ diameter throat. The curves shown in Fig. 4 show the effect of varying the ratio of submersion to lift. Values being plotted for given free air consumption per cubic foot of pulp, and also for efficiencies at different ratios, the efficiency and consumption of air as ordinates and ratios of submersion to lift as abscissæ. It will be noticed that the point of maximum efficiency under the conditions of test is where the ratio = 1·83 to 1, giving an efficiency of 36.2 per cent. It will also be seen that the free air consumption curve becomes almost flat after this ratio is increased. The ratio of air to pulp not decreasing after this point, and the submersion increasing, the working air pressure, and, of course, the air horse-power per cubic foot of free air, is increased, this decreasing the efficiency.

	Test.	I.	M.
Conditions.	Date	27-9-06	27-9-06
	Tube	West	East
	Number and size of tubes used	One 12 to 14in.	One 14 to 16in.
	Submersion, in feet	48·24	52·528
	Lift, in feet.	26·8	26·8
	Ratio submersion to lift .	1·8 to 1	1·96 to 1
	Working gauge pressure, in lb. per sq. in.	21·5	24·0
	Average number of stamps running	180	180
	Kind of foot piece	Small, Fig. 2	Large, Fig. 2
	Throat diameter of foot piece	11½in.	13½in.
Performance.	Free air per min., in cub. ft.	893	822·5
	Free air per min. per stamp, in cub. ft.	4·96	4·56
	Free air per cub. ft. of slimes, in cub. ft.	2·48	2·28
	Cub. ft. of slimes per min. .	360	360
	Cub. ft. of slimes per stamp per min.	2	2
	Throat velocity, in cub. ft. per second... . .	8·34	6·03
	Theoretical horse-power ...	18·49	18·49
	Horse-power per cub. ft. of free air compressed... ...	·063	·068
	Air horse-power	56·26	55·93
	Efficiency, per cent.	32·7	33·1

TABLE II.—AIR LIFT TESTS AT ANGELO SLIMES PLANT.

Table IV. Tests M, N, O, P, Q and R.—This series of tests was carried out on the same day. The same sizes of tube, foot piece

and throat diameter were used, the same number of stamps were running—therefore the cubic feet of pulp to be lifted or dealt with per minute was constant—and the same throat velocity was attained, the varying conditions being the submersion and lift. The ratio submersion to lift varied from 1·96 to 1 to 1·01 to 1. The consumption of air to slimes varied from 2.28 to 7.83 cubic feet of free air per cubic foot of pulp, and the efficiency from 33.1 per cent. to 17.5 per cent. The tests seem to show pretty clearly that the most economical ratio is somewhere in the vicinity of 1·96 to 1 under these conditions.

Table III.—*Air Lift Tests at Angelo Slimes Plant.*

	Test.	M.	S.	T.
Conditions.	Date	27-9-06	2-10-06	3-10-06
	Tube	East	East	East
	Number and size of tubes used	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.
	Submersion, in feet	52·528	46·9	40·2
	Lift, in feet	26·8	26·8	26·8
	Ratio submersion to lift	1·96 to 1	1·75 to 1	1·5 to 1
	Working gauge pressure, in lb. per square inch	24	21·5	18·75
	Average number of stamps running	180	187	175
	Kind of foot piece	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2
	Throat diameter of foot piece	13½in.	13½in.	13½in.
Performance.	Free air per minute in cubic feet	822·5	841·3	899·3
	Free air per minute per stamp in cubic feet	4·56	4·50	5·13
	Free air per cubic foot of slimes, in cubic feet	2·28	2·33	2·81
	Cubic feet of slimes per minute	360	360	320
	Cubic feet of slimes per stamp per minute	2·0	1·92	1·82
	Throat velocity, in cubic feet per second	6·03	6·03	5·36
	Theoretical horse-power	18·49	18·49	16·44
	Horse-power per cubic foot of free air compressed	·068	·063	057
	Air horse-power	55·93	53·002	51·26
	Efficiency, per cent.	33·1	34·8	32·0

TABLE III.—AIR LIFT TESTS AT ANGELO SLIMES PLANT.

	Test.	M.	N.	O.	P.	Q.	R.
Conditions.	Date	27-9-06	27-9-06	27-9-06	27-9-06	27-9-06	27-9-06
	Tube	East	East	East	East	East	East
	Number and size of tubes used	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.
	Submersion, in feet	52·528	46·292	45·696	43·978	39·895	39·895
	Lift, in feet	26·8	32·6	33·6	35·9	39·5	39·5
	Ratio submersion to lift	1·96 to 1	1·42 to 1	36 to 1	1·22 to 1	1·01 to 1	1·01 to 1
	Working gauge pressure, in lb. per square inch	24	22	21·5	20	19	18
	Average number of stamps running	180	180	180	180	180	180
	Kind of foot piece	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2
	Throat diameter of foot piece	13½in.	13½in.	13½in.	13½in.	13½in.	13½in.
Performance.	Free air per minute, in cubic feet	822·5	1175	1410	1880	2350	2820
	Free air per minute per stamp, in cubic feet	4·56	6·52	7·83	10·44	13·05	15·66
	Free air per cubic foot of slimes, in cubic feet	2·28	3·26	3·91	5·22	6·53	7·83
	Cubic feet of slimes per minute	360	360	360	360	360	360
	Cubic feet of slimes per stamp per minute	2	2	2	2	2	2
	Throat velocity, in cubic feet per second	6·03	6·03	6·03	6·03	6·03	6·03
	Theoretical horse-power	18·49	22·49	23·18	24·77	27·25	27·25
	Horse-power per cubic foot of free air compressed	·068	·064	·063	·060	·058	·055
	Air horse-power	55·93	75·2	88·83	112·8	136·3	155·66
	Efficiency, per cent.	33·1	29·8	26·1	22·0	20·0	17·5

TABLE IV.—AIR LIFT TESTS AT ANGELO SLIMES PLANT.

Table V. Tests I, J, K and L.—The conditions of this test are very similar to those in Table IV. The ratio of submersion to lift varying from 1·8 to 1 to 1·41 to 1. The size of tube was different, the tube used being a 12 inches widening to 14 inches diameter. The foot piece was the same size new type. The difference of throat area raised the velocity to 8.3 feet per second compared with 6.03 feet per second in tests of Table IV. The average efficiency obtained was less than the average efficiency between the same limits of ratio submersion to lift in Table IV., thus suggesting that the throat velocity in the tests of Table V.

were too high. The same suggestion arises on comparing tests D and E, Table I., where the velocities are 4.855 and 7.39 feet per second and the efficiencies 36.15 per cent. and 30.55 per cent. respectively.

and were designed for much greater duties; the revolutions were therefore very low, and better results would have been obtained with small compressors driven by belts from the battery line shafts.

	Test.	I.	J.	K.	L.
Conditions.	Date ...	27–9–06	27–9–06	27–9–06	27–9–06
	Tube ...	West	West	West	West
	Number and size of tubes used ...	One 12 to 14in.	One 12 to 14in.	One 12 to 14in.	One 12 to 14in.
	Submersion, in feet ...	48·24	45·44	44·51	43·85
	Lift, in feet ...	26·8	29·7	30·7	31·1
	Ratio submersion to lift ...	1·8 to 1	1·53 to 1	1·45 to 1	1·41 to 1
	Working gauge pressure, in lb. per square inch ...	21·5	20·7	20·5	20
	Average number of stamps running ...	180	180	180	180
	Kind of foot piece ...	Small, Fig. 2	Small, Fig. 2	Small, Fig. 2	Small, Fig. 2
	Throat diameter of foot piece ...	11½in.	11½in.	11½in.	11½in.
Performance.	Free air per minute, in cubic feet ...	893	1222	1410	1880
	Free air per minute per stamp, in cubic feet ...	4·96	6·78	7·83	10·44
	Free air per cubic foot of slimes, in cubic feet ...	2·48	3·39	3·91	5·22
	Cubic feet of slimes per minute ...	360	360	360	360
	Cubic feet of slimes per stamp per minute ...	2·0	2·0	2·0	2·0
	Throat velocity, in cubic feet per second ...	8·34	8·31	8·31	8·31
	Theoretical horse-power ...	18·49	20·49	21·18	21·45
	Horse-power per cubic foot of free air compressed ...	·063	·0612	·061	·06
	Air horse-power ...	56·26	74·78	86·01	112·8
	Efficiency, per cent. ...	32·7	27·35	24·65	19·0

TABLE V.—AIR LIFT TESTS AT ANGELO SLIMES PLANT.

Two tests, shown in Table VI., were carried out on the Cason property, one each with one of the sands and one of the slimes tubes. The same methods were employed as in the Angelo tests, with the exception that the measurements of the pulp were determined by diverting the flow into the well of an idle "lift" which had been previously calibrated. The following additional details were determined.

Specific gravities.—The specific gravity of the slimes was taken as in the Angelo tests; that of the sands was found to be 1.033, or 64.56 pounds per cubic foot. The theoretical horse-power was calculated on this basis. Theoretical horse-power for sands lifted:—

$$\text{Theo. H. P.} = \frac{\text{Quantity of sands by } 64{\cdot}56 \times \text{lift in feet}}{33{,}000}$$
$$= C_1 \times Q \times h_2 = \frac{64{\cdot}56}{33{,}000} \times Q \times h_2$$
$$= {\cdot}001956 \times Q \times h_2.$$

"Sands" means the mixture of crushed ore and water coming from the reduction plant, from which, however, the "slimes" have been removed.

It will be seen from the tests that, under the best conditions, an efficiency of close upon 40 per cent. of the indicated horse-power in the steam cylinders of the air compressor was returned as work performed in lifting the pulp. The tests were handicapped by the fact that the air compressors used were far too large,

There is ample proof in the tests as tabulated that the air lift is, if carefully designed for stated conditions, sufficiently efficient to make it a healthy competitor of the ordinary tailings wheel, and it is proved, beyond ques-

	Test.	1.	2.
Conditions.	Where at ...	Sands Plant	Slimes Plant
	Date ...	21–7–07	26–7–07
	Tube ...	North	East
	Number and size of tubes ...	One 12 to 14in.	One 14 to 16in.
	Submersion, in feet ...	78·17	37·54
	Lift, in feet ...	43·0	17·33
	Ratio submersion to lift ...	1·817 to 1	2·166 to 1
	Working gauge pressure, in lb. per sq. in. ...	34·5	11·785
	Average number of stamps running ...	215	210
	Number of tube mills running	2	2
	Kind of foot piece ...	Small, Fig. 2	Large, Fig. 2
	Throat diameter of foot piece	11½in.	13½in.
Performance.	Free air per min., in cub. ft.	892·5	854·57
	Free air per min. per stamp, in cub. ft. ...	4·155	4·07
	Free air per cub. ft. of pulp, in cub. ft. ...	2·418	1·871
	Cub. ft. of pulp per min. ...	369	456·7
	Cub. ft. of pulp per stamp per min. ...	1·71	2·17
	Throat velocity, in cub. ft. per second ...	8·526	7·612
	Theoretical horse-power ...	31·05	15·182
	Horse-power per cub. ft. of free air compressed ...	·088	·0475
	Air horse-power	78·54	40·706
	Efficiency, per cent. ...	39·5	37·206

TABLE VI.—AIR LIFT TESTS AT CASON SLIMES AND SANDS PLANTS.

tion, more suitable than the tailings pump. The capital cost of a duplicate equipment of air lifts is very low compared with that of wheels or pumps, provided low-pressure air compressors, driven from the mill shaft, are employed.

As the lifts and compressors would be in duplicate, the stoppage of work due to breakdowns of the pulp lifting devices is avoided, and one day's stoppage per annum would more than cover any increase in power costs. There is the further advantage that any large increase in the amount of material to be lifted does not necessitate the rejection of the plant installed, as tubes of sufficient capacity to meet the increased demand can be added to the installation, and two or more tubes run in parallel. Except as an emergency pump the air lift is too inefficient to replace power pumps for pumping clean, pure water. For dirty or acid water, sands or slimes, under comparatively low heads, it is a most valuable device, and, if properly arranged, is hard to beat. If not properly designed it is a tremendous power eater. This latter characteristic is well exemplified by the fact that if the contents of the well become aerated, through compressed air leaking back from the foot piece, a practically unlimited amount of compressed air will be absorbed by the lift, and the discharge from the tube will be of the nature of a fine spray blown out by the air. Under such circumstances it can be well understood that the efficiency of the plant would drop to an almost negligible quantity. It can be accepted as an axiom with air lifts that unless the discharge is a comparatively steady flow, free from pulsations, the best results are not being attained and, in all probability, the ratios of lift and submersion are not correctly proportioned.—*The Engineer,* London.

MINE VENTILATION

It is generally considered that a miner requires 20 cubic feet of air per minute, and a horse 90 cubic feet, but allowing for the air necessary to drive away fumes of explosives, the products of combustion from lights and other impurities, a much larger quantity of fresh air is required. In Prussia 70 cubic feet of air per minute is allowed for each man; the Victorian Mining Act requires the same amount. Pure air may be considered to consist of 79 per cent. of nitrogen by volume and 21 per cent. of oxygen. As a matter of fact, it also contains small quantities of other gases, chiefly carbon dioxide. One should aim at keeping the percentage of carbon dioxide as low as possible, and the oxygen above 20.5 per cent. Mine air may be fouled by gases given off by rocks and minerals, such as carbon dioxide, sulphurous anhydride, marsh gas from decaying timber, light, fuel, respiration of man and beast, perspiration, want of proper sanitary arrangements, and from blasting, which gives off carbon dioxide, carbon monoxide and nitrous fumes. An increase in temperature due to depth, heat from the body, combustion, exhaust steam, steam pipes, chemical decomposition—all require extra air to make life below ground healthy. Some of these vitiating causes may, and should be, greatly mitigated. For instance, proper attention to sanitary arrangements, the destruction of old timber and the barking of timber instead of leaving it to rot underground, and seeing that good explosives are employed and properly fired. The method of working a deposit may greatly facilitate ventilation. The problem of ventilating a lode mine is quite different to that of a bed mine such as a coal seam or deep lead. Lode mines are more or less vertical, and, from their nature, have several outlets to the surface; a bed mine is generally under cover, so that the inlet and outlet air has to pass through certain artificial passages which can be regulated as desired. To force air into or suck it out of an ordinary lode mine would cause short-circuiting unless pipes were used direct to the place to be ventilated, but in bed mining the cover generally acts as an effectual preventive for natural short-circuiting. Therefore, while it is fairly easy to supply a given quantity of air per man in a colliery, it is by no means so easy in a lode mine; for though the air may be provided at its source, in most cases it will be dissipated before reaching the desired point if discharged direct into underground passages. The ventilation of mines may be natural, assisted natural, or artificial. In difficult cases, artificial means have to be resorted to. These generally consist of some form of fan, which induces a large current of air at a low pressure. Certain principles governing ventilation may be laid down, but how they are to be applied depends on local conditions in each instance.

THE ATLANTIC OCEAN AS AN AIR COMPRESSOR

The tides in their rise and fall suggest in that action an unlimited and unfailing source of power. The utilization and convenient employment of this power has been an engineering problem of the ages, and up to the present little practical success has been achieved. The power, while costing nothing in itself, still must involve large expenditure for the arrangements made and the means employed for its development and transmission. One of the most interesting, and we may say also most promising of these schemes of utilization is that now under way at Rockland, Maine, under the impetus and direction of a competent and experienced engineer, Mr. W. O. Webber, of Boston, who has presented a concise account of his undertaking in a recent issue of the *American Machinist.* This account, somewhat abridged, we here reproduce.

This is not an application of the Taylor system of air compression, which has been so successfully employed at several waterfalls in different parts of the country, but is really a return to the older methods of Frizell, with modern improvements.

Careful experiments upon a large working model erected at South Thomaston, Maine, las summer, have fully demonstrated the peculiar application necessary to the utilization of the flow between large tidal basins and the ocean, and have demonstrated that an economical compression of air can be accomplished with much less differences in water level than was claimed by Frizell. At South Thomaston, Maine, there is a tidal basin with an area of slightly over a square mile. The average rise and fall of the tide at this point is 10 feet. This would, therefore, realize about 5,000 horse-power on the basis of 75 per cent. efficiency of the compressing apparatus, which should be easily obtained, as the tests of the other plants mentioned have given much higher values.

The "head of fall," or the difference of level in the case of tidal flow, simply governs the ratio of air that can be entrained with a given volume of water, and has nothing to do with the pressure. The depth below the surface at which the separation of the entrained air from the water takes place, governs the pressure, and it has been demonstrated that with a fall of 35 feet the highest ratio of efficiency can be obtained, that is, the maximum ratio of air to water.

It is easily practicable to arrange for storage chambers, connected with the separating chamber, sufficiently large to store air to the average capacity of the compressor, to cover the period of time at flood and ebb tide when the compressor would either not work at all or at such low efficiencies as to be commercially worthless.

It is practicable to transmit compressed air through pipes to long distances with comparatively slight losses. The leakage is negligible. As hydraulically compressed air contains no entrained moisture, the frictional resistance is remarkably low, and velocities of 50 to 70 feet a second are admissible. The cost of pipe lines is not greatly in excess of electrical transmission lines when the cost of step-up and step-down transformers for high voltage is taken into consideration.

There are many tidal basins along the coasts of the temperate zones between the fortieth and fiftieth parallels of latitude which are commercially capable of development in this manner with an unfailing source of power. This power can be made available for many miles inland from the shore at a comparatively low cost and, with the single exception of lighting, can be turned into useful work in its original form in strict competition with electrical power.

Work will begin at Rockland early next spring on the construction of the dam, laying the pipe lines to the quarries of the Rockland Rockport Lime Company, to the power-house of the Rockland, Thomaston & Camden Street Railway and also to several cities in whose streets distribution mains will be laid the same as gas pipes. It is expected that the plant will be completed in the fall of 1908.

THE ROCKLAND DEVELOPMENT.

Fig. 1 shows details of the lock and inlet and outlet gates, Fig. 2 a partial general plan and section of the complete construction at the same point. The maximum tide is 10.6, mean tide 9.4 and minimum tide 7.9 feet, giving, respectively 5,000, 4,000 and 3,000 horse-power. In this dam, where the main channel is navigable, will be a lock for vessels 40 feet wide by 200 feet long and 28 feet deep. On either side of this lock will be one or more sets of shafts, each set making a unit or compressor of 1,000 or more horse-power. These shafts will be sunk into the rock to a depth of 203.5

feet below mean low water, the down-flow shaft being 15.75 feet in diameter, the up-flow shaft 35.65 feet in diameter. The inflow gates will be five in number and 10 feet wide. The outflow gates will be six in number and 10 feet 8 inches wide.

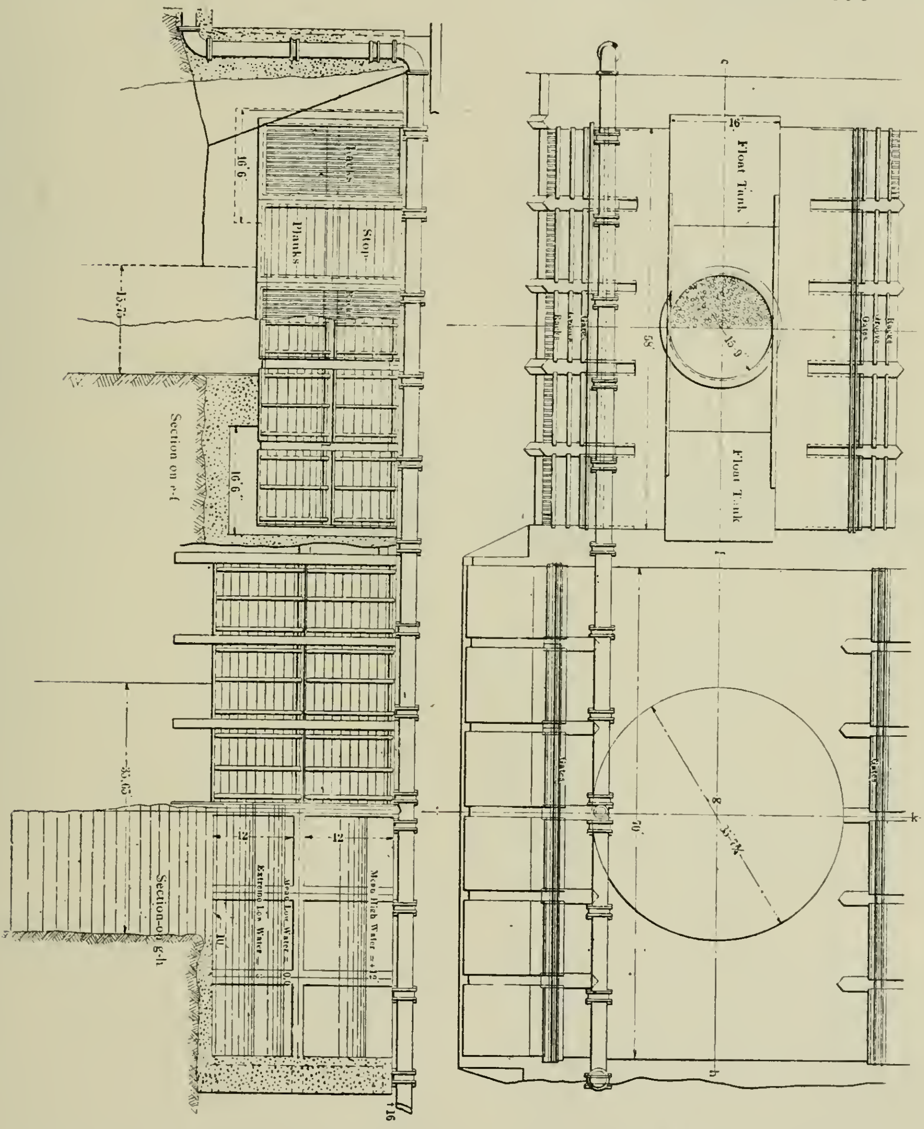


FIG. 1.—DETAILS OF INLET AND OUTLET TUBES, TANKS, ETC.

The water on entering the inflow gates will swing them open, pass down the down-flow shaft at a velocity of 16 feet per second and draw in air through about 1,500 half-inch inlet tubes. At the bottom of the shaft the combined air and water will flow in both directions horizontally; the air will separate from the water and accumulate in the upper part of the separating chambers. The water will then flow up the up-take shaft at a velocity of 3 feet per second and out through the out-flow gates. The air entrapped in the air chamber is then under a head of water about 195.5 feet high, varying slightly with the height of the tide. This compressed air is then led up the up-flow shaft in a 14-inch pipe. At the top of the gates these 14-inch pipes are united into a 30-inch main which conveys the air ashore.

The air thus compressed will contain only about one-sixth the moisture that is in the atmosphere from which the air is drawn, owing to the absorption of the moisture in the compressed air by the surrounding water. This dryness makes the air particularly adaptable for transmission in pipes to a considerable distance without undue friction. For instance, the whole 5,000 horse-power could be transmitted a distance of 1 mile in a 30-inch pipe with a loss of only 1.5 pounds pressure, or 10 miles in a 48-inch pipe with only a loss of 2.5 pounds pressure. This air can be used cold without danger of freezing in expanding in engines or rock drills. A test was made on an 80 horse-power Corliss engine in which the entering air was at a temperature of 5.3 degrees Fahrenheit and the exhaust at minus 40 degrees Fahrenheit. The engine ran for 10 hours without the slightest sign of frost in the exhaust ports, passages and pipes. A marked economy, however, is obtained by preheating this air immediately before using it.

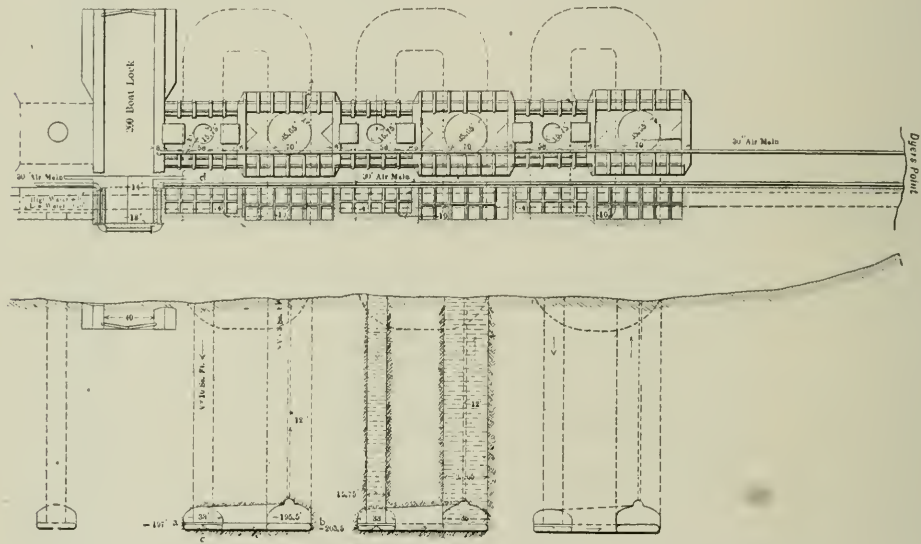


FIG. 2.—PLAN AND PARTIAL VERTICAL SECTION OF TIDAL AIR COMPRESSOR.

There are no working parts in the compressor, therefore little depreciation and operating expense to be taken into account, excepting a watchman to prevent depredations on the plant, keep ice, floating timbers and debris from permanently obstructing the inlet racks and to operate the boat lock. Therefore, the cost per horse-power is practically represented by the interest on the original investment and the wages of these watchmen. The cost of original construction will amount to $100 per horse-power.

It is a rather curious fact that, as a rule, in the temperate zones where the population is largest the maximum rise and fall of the tide occurs. This maximum tidal action results in the "wearing out" or excavating by means of tidal abrasion of basins in the coast, usually with a comparatively narrow outlet, conditions which are necessary for an economical development of a tidal air-compressing plant. Each acre of such basin under a 9-foot tide is capable of producing 5 horse-power. It is not commercially feasible to develop such a plant with a basin containing much less than 200 acres, or requiring a length of dam exceeding 3 feet per acre of pondage.

RECENT HIGH PRESSURE GAS INSTALLATIONS AT SAN FRANCISCO AND ITS VICINITY

The following is a paper, nearly complete, read at a recent meeting of the Pacific Gas Association by Mr. E. C. Jones, chief engineer, Gas Dept., California Gas and Electric Corporation and San Francisco Gas and Electric Company:

In the early days of gas lighting on the coast there was a small coal-gas works at San Mateo, twenty-one miles from San Francisco, and later on an oil-gas plant was built at Redwood City. After the usefulness of high-pressure systems had been demonstrated, a high-pressure line consisting of 2½-inch extra heavy pipe, with line pipe sockets, was laid from Redwood City to San Mateo, 8.2 miles. On this pipe a pressure of from 10 to 30 pounds is maintained, depending upon the demand for gas. This line feeds into a high-pressure district in San Mateo, which includes 63,490 feet of 1 and 2-inch pipe. The consumers in this town are served with gas through high-pressure regulators at the inlet of each meter. This permitted the shutting down and dismantling of the San Mateo gas works.

A high-pressure system was also installed at Redwood City, consisting of 5,410 feet of steel pipe in small sizes. This is used in conjunction with a low-pressure system at Redwood City fed from the gas works by one governor, reducing the pressure to 4 inches of water. The work of compressing the oil gas at Redwood City was performed by a steam-driven compressor, with suitable governors for regulating the high pressure of San Mateo and the high and low pressure mains of Redwood City.

During the early part of 1905 Palo Alto, a city of 4,500 inhabitants, five miles south of Redwood City, was piped for gas with small, high-pressure mains, using individual governors. This work was done by the Palo Alto Gas Company. This new company purchased its supply of gas from the Redwood City plant. To supply this district, 3-inch outside diameter steel tubing, 26,365 feet in length, was laid in the country road, and four storage tanks, 29½ feet in length by 4½ feet in diameter, were installed at the Palo Alto end of the line.

In casting about for a suitable place to locate the storage tanks at Palo Alto, it occurred to the writer that it was not necessary to purchase or rent real estate for the purpose of placing gas storage tanks above ground, as many gas companies all over the world are occupying the streets with gas mains of greater diameter than these storage tanks. The tanks were, therefore, placed under ground in a tandem sequence closely surrounded by earth, the regulators occupying spaces between the tanks in neat boxes with covers flush with the surface of the ground. This arrangement is both safe, inoffensive and economical. This high-pressure line is operated under pressure varying from 40 to 60 pounds, and to insure continuous service it became necessary to install an electrically-operated compressor at the Redwood City plant, retaining a gas-engine-driven compressor as a reserve.

To improve the service, and to permit of better regulation, a storage tank was installed at the Redwood City works, and into this tank all the gas used by Redwood City, San Mateo and Palo Alto was pumped. The gas was liberated through separate governors, giving to each of the three places the required pressure. At that time the effect of compression on candle power was being widely discussed and was but little understood. All that was known was that the illuminating value of the gas suffered almost directly proportionally to the increase in pressure.

EFFECT OF COMPRESSION ON THE GAS.

It was evident that the raising of the pressure to 60 pounds on the Palo Alto line reduced the candle power 4.6 candles. The compression liquid, depending in quantity on thermal conditions and the amount of pressure, was being drawn out of the drips on the line. This liquid consisted of water, naphthaline, and a high grade of benzol. This benzol represented the cream of the candle power of the gas, and consisted of the least stable and most sensitive hydrocarbons which were squeezed out of the gas by compression.

The writer inferred that the compressed gas at 60 pounds pressure was nearly free from water, and was, therefore, in the best condition to readily and quickly take back into itself the hydrocarbons which had been squeezed out of it; also, that the hydrocarbons would more readily be taken up and again enter into the composition of the gas than the water would be, because the benzol evaporates so much more readily than does water.

The physical changes in the gas due to compression, and to the restoration of the candle power, are in the following sequence: The compressor squeezes out the water and some of the hydrocarbons, and, in order to replace the hydrocarbons, it becomes necessary to keep the gas in intimate contact with the fluid resulting from compression. To do this the writer designed an extremely simple piece of apparatus, and gave it the name of auto-enricher. It is a simple cylinder, preferably of large size, into which all of the compressed gas and the fluid of compression as they came from the compressor enter at one end at the top, and the gas is taken out at the other end at the top, care being taken that the passage of the gas is slow, and that none of the liquid is allowed to escape from the auto-enricher except as it is taken up by the gas. Such a re-enriching tank was placed underground at the Redwood City plant, with the result that the candle power at San Mateo, Redwood City and Palo Alto was restored to its original condition before compression.

Further experiments (which were subsequently made the subject of a paper by the writer, read before the American Gas Institute) proved that, by raising the compression, certain physical changes took place in the gas, until at 300 pounds pressure the gas was completely purified from sulphuretted hydrogen and naphthaline, these going down with the compression fluid and not reappearing in the gas when the benzol is taken up by the gas in the re-enriching tank.

LARGEST OIL GAS PLANT.

In 1905 the largest oil gas plant in the world was designed and constructed, on new lines, at a point on the bay of San Francisco in San Mateo County, in close proximity to the San Francisco border line, and was named for our president, Martin Station. This plant was built for the purpose of supplying gas to a number of large gas engines for directly generating electricity. Before the completion of these engines the gas generating plant was finished and started.

To utilize this enormous plant a 12-inch steel tubing was run along the country roads into San Francisco, and connected with the works of the San Francisco Gas and Electric Company at the Potrero Station. The length of this line is 4½ miles, and a steam-driven compressor was used for transferring the gas. This proved so satisfactory that it became the nucleus of the largest compression plant for manufactured gas in existence. Two power-driven compressors were installed, each having a capacity of 5,500,000 cubic feet of gas in 24 hours. Following the growth of this plant, the gas engines, three in number, each of 5,333 horsepower, were completed and successfully started. Between Martin Station and the south is the high ridge of the San Bruno Mountains, but west from Martin Station there is a gap through the range, which permits of a practically level outlet into the county roads leading from San Francisco down the peninsula to the south. It required the earthquake, which is not yet effaced from our memory, to bring out the fact that Martin Station is a desirable point from which to supply gas to the cities and towns of the peninsula through high-pressure mains.

EARTHQUAKE-PROOF PIPING.

The peninsula towns were directly in the path of the earthquake's greatest destruction, but as the high-pressure mains and nearly all the distributing mains in this section were of wrought iron, not the slightest damage was done to the distributing system—this is true of all the high-pressure systems in California. No wrought iron pipe was broken and no joints were disturbed.

The Redwood City gas works, however, did not fare so well. The boiler settings were badly damaged, and the gas-generating apparatus was moved several inches on its foundation, while all cast-iron connections were more or less damaged. A 20,000 cubic foot gasholder, in a redwood tank, was completely demolished. This adjustment of matters by the earthquake made it much easier to decide to supply this district from Martin Station.

On February 23, 1907, the work of laying a 4-inch steel tubing from Martin Station to Redwood City, a distance of 125,295 feet, or, 23.73 miles, was begun. The inside diameter of this tubing is 3.7 inches. This pipe passes through the following suburban towns, all of which receive gas from it: Burlingame, population 900; San Mateo, 4,600; Belmont, 500; Redwood City, 2,500; Fair Oaks, 250, and the Palo Alto extension, including Menlo Park, with a population of 1,200, and Palo Alto, 4,500, making a total population of 14,450.

This high-pressure line was laid with Dresser couplings, using rubber gaskets, the flanges of the joints being drawn up tightly and evenly to prevent the contact of the gas with the rubber as much as possible. It is quite important, in using this patent coupling, that the tightening of the bolts shall proceed evenly, so that the flanges may remain parallel. Should one side of the flange be drawn up more than another, the pressure on the rubber gasket is uneven, and the flange is apt to bind on the pipe so that a leak is almost certain.

The painting of this line was a matter of some study, as it has previously been found that red lead and linseed oil of the best quality, although offering a good protection to the pipe, would not withstand the attacks of either air or the soil. This pipe was, therefore, first thoroughly cleaned and painted with one coat of red lead and oil, then given a second coat of a good and well-proven metallic gasholder paint which dries with a hard, shiny finish. It is hoped that this covering will be more durable than those formerly used.

A new pattern of drip-box was used on this line, and 25 of them were located at various low points throughout the length of the pipe. High-pressure valves made for the purpose of holding ammonia were placed in the line at five different points, at the approach of each town. These valves were connected into the line by means of an adapter to permit the connecting of a Dresser coupling with a flanged valve. The drip-box is provided with half a Dresser coupling on each side to facilitate its being connected into the line.

No other fittings are used in this line with the exception of six crosses, one at each town. These crosses are provided with adapters to Dresser couplings, and all right angles are turned by bending the pipe at a uniform radius of 20 feet.

At the completion of each day's work the line was capped and air pressure applied to it, up to 100 pounds per square inch. This pressure was allowed to remain on the line the entire night. Testing for small leaks was done by the use of soap-suds and a brush, the soap-suds being applied to all parts of the coupling and to the pipe for a distance of 2 feet each side of the coupling, as this seems to be the vulnerable place where the pipe is apt to be split.

TESTING FOR LEAKS.

One of the details developed in connection with testing for leaks is the fact that thick soap-suds, which has been mixed for several days, is better than soap-suds quickly and imperfectly mixed. The importance of careful testing is evident when it is stated that 182 defective sleeves and 29 lengths of split pipe were discarded on this line.

Much of the work was done during uncertain spring weather, and a plow could not always be used to advantage, so that it was necessary to do much of the work with pick and shovel. A grader was used for refilling, and all of the trench after being filled was carefully sprinkled and rolled.

The line was completed June 1, 1907. The actual working days required were seventy-five The average amount of pipe laid each day was 1,660 feet, while the greatest amount laid in a single day was 3,200 feet. The average depth of the pipe is 2½ feet. The line was placed in commission Thursday, July 18, 1907, and not a single leak developed in any part of the line.

The gas is pumped into the line by a 14×16×12-inch steam-driven compressor, with a mechanical efficiency of 85 per cent., requiring 55 horse-power, under the present conditions. This compressor has a capacity of about 22,500 feet per hour. The gas is first forced through an auto-enricher tank, alongside of which is a storage tank.

These tanks are 6 feet in diameter by 32 feet long, and have a capacity of 875 cubic feet. The line itself has a capacity of 9,375 cubic feet. The 25 drips on the line have a combined capacity of 19 cubic feet, and the receiving tank at Redwood City, 380 feet. The total capacity of the tanks and line is 11,524 feet. The gas is received at Redwood City into a storage tank 5 feet in diameter by 26 feet long. This tank is used for receiving all the gas. and from it the various lines are fed through governors.

Four compression tanks, 6 feet in diameter by 32 feet long, are located at Redwood City, as a reserve storage to be used in the event of an accident to the compressing machinery, or on the pipe line. The gas is taken from the receiving tank and pumped by means of a motor-driven compressor into the four storage tanks at a pressure of 80 pounds. This boosting arrangement is a temporary expedient for present convenience, and is capable of many changes, as the storage tanks may be filled directly from the line and discharged automatically through the present governors whenever there is a drop in the pressure At the present time, approximately 100,000 cubic feet of gas per 24 hours is consumed through the Redwood City high-pressure line, and the line is so free from defects, and the storage capacity of the line and the three tanks (disregarding the four storage tanks at Redwood City) is so large, that the compressor at Martin Station is only operated a portion of the time.

This 4-inch O. D. line has an actual capacity at 5 atmospheres, or 58.8 pounds pressure, of 57,620 cubic feet, or an available capacity at that pressure of 46,096 feet. In speaking of atmospheres in reference to pressure, it must be remembered that when we say that we have 5 atmospheres in a tank, we do not mean five available volumes of the tank, but four available volumes, and 58.8 pounds gage pressure, there always being one volume or atmosphere that is not available or apparent on the gage, and which cannot be gotten out except by exhausting the tank to a vacuum, or filling it with water.

This line completely installed cost 1½ times as much as a 2-inch outside diameter line which would have an actual inside diameter of 1.782 inches. It has an actual holding capacity of 4.3 times as much as a 2-inch O. D. line, and its carrying capacity at equal pressures is 5.75 times that of the 2-inch O. D. line.

This installation is amply large to provide for the growth of the southern suburbs of San Francisco for many years, and will insure excellent service to the best class of gas consumers, the average monthly consumption per meter of these consumers being 4,570 feet, which is in excess of that of most of our large cities.

In conclusion, the writer may be permitted to apply a very old saying to high-pressure gas distribution, that, like fire, it is a good servant, but a bad master.

PURIFICATION OF SEWAGE AND POLLUTION OF ATMOSPHERE

Disagreeable though it may be to the average person, the damp and unpleasant atmospheric conditions which prevail in Lancashire are the county's chief asset. But although a humid atmosphere may conduce to successful cotton spinning, there is, fortunately, no necessity for a solid element in the air. The paper read in Manchester recently by Mr. R. H. Clayton shows that by analysis the polluting matter in Manchester air approximates most nearly to that of the smoke from domestic chimneys, being charged with tarry oils, ammonia and solid ash, which are only emitted from boiler chimneys in insignificant quantities. The author demonstrated the resemblance which exists between the domestic fire-grate and the gas retort in the process of distillation of the fuel going on in each, but with the essential difference that the products of distillation are in the case of the household fire-grate poured into the atmosphere, while in the retort they are collected and used as valuable industrial materials. As an argument in favor of domestic gas fires Mr. Clayton made the significant statement that while on the one hand the citizens of Manchester spend annually £64,000 on the purification of sewage to prevent the pollution of rivers, yet, on the other hand, the purification of the atmosphere was retarded by the city fathers by charging for municipal gas such a price that an annual profit of £60,000 from its sale was set aside for the relief of the rates.—*The Engineer, London.*

A RECORD JUMP IN BRIDGE DESIGN

The fall of the uncompleted Quebec bridge was the disastrous event by which the year 1907 will be recorded in the history of bridge building. It points to a danger of engineering conceding too much to commercialism. The company had a certain amount of money, and wanted a great bridge built within the limit. That is not the way in which monumental works are erected.

* * * * * * * *

Designs have been made for a reinforced concrete arch bridge which exceeds the Quebec bridge in boldness. While the present largest masonry arch bridge is less than 300-foot span, and the largest concrete arch bridge only 233-foot span, the new design is for a clear span of 703 feet. It is the main span of a proposed Hendryk Hudson Memorial Bridge, to cross the Spuyten Duyvil Creek in New York City. The designs call for a concrete rib 70 feet wide, 28 feet thick at the haunches, and 15 feet at the crown, with spandril arches to carry the roadway. The rise is 177 feet. The compressive stress on the concrete is limited to 750 pounds, and the amount of steel required for reinforcement in compression is said to be greater than for a steel arch bridge. The difficulties of erection at the site are extreme, and the Quebec bridge investigation has shown that while it is easy to design a bridge in the drawing office, the matter of erection can not be overlooked with impunity. The failure of the Quebec bridge might well give pause to the office designer or engineer who plans a concrete arch of 700 feet span when nothing larger than 233 feet has yet been attempted.—*The Engineer* (London).

COMPRESSED AIR
AND EVERYTHING PNEUMATIC
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THE SCOOP VICE

In the chronicling of the events of the day, which are to be forgotten to-morrow, and accounts of which are absolutely valueless if not fresh, the struggle is always to get the news first, and if at the same time one can have the exclusive rush of it this is the supreme triumph of the reporter and the editor. The scoop is rightly the brag of the daily news man, but what has it to do with the collector and disseminator of permanent and especially of technical information? Such matter is really as good to-morrow or next week or next month as to-day, and yet the scoop habit of the daily press lingers with the conductors of technical periodicals, with the result that in many cases their readers are defrauded of their rights.

The conductor of a technical publication, such, for instance, as COMPRESSED AIR, or any other, the lines and limits of which are defined with reasonable clearness, is understood to have a standing and continuous promise to its readers and supporters to keep them informed and up-to-date in the special lines indicated by telling them all, properly sifted, of course, that comes to their knowledge or which they can procure concerning the new methods and means as they are continually developing and by way of stimulus about the rates of accomplishment which are constantly advancing. Any publication which deliberately withholds from its readers any matter of importance which has just become ripe for publication merely because it cannot have the first or the exclusive handling of it is not treating its constituents honestly, and after long observation of the practice we fail to discover the policy of it.

We were flattering ourselves that while we are not free from human weaknesses we were not afflicted with this particular vice when along came the article with which our present issue begins. If we could be tempted and led away we would be exulting and peradventure boasting over the fact that we are the first to publish the matter therein contained. There is no need of our calling attention to the fact that the making of liquid air cheaper than beer and by means which must be entirely approved by both the scientist and the mechanic is a notable achievement. Liquid air may now be produced in such quantities and at a cost so low that a large field for its employment is thrown open in the production of both oxygen and nitrogen in large volume for various industrial purposes, and other uses must inevitably develop.

The second long article in the present issue, with apologies and regrets for the length in each case, gave a more pertinent illustration of the possible working of the scoop vice. It happened that the reports of the tests of the Air Lift in South Africa came to the editorial office of COMPRESSED AIR a couple of months ago and were in process of preparation for our columns when the article embodying the same material appeared in admirable form in *The Engineer*. If the scoop vice had been in complete ascendency in this office the matter would have been dropped at once, but instead we reproduce the entire article of *The Engineer*, and our readers surely have nothing to regret.

PROGRESS ON THE RAND

The two paragraphs below are from the latest-to-hand issue of *South African Mines:*

AIR PIPES AND PRESSURES.

Some weeks ago we published a series of tables showing the carrying capacities of underground air pipes of various sizes for various distances, and we are gratified to find that, largely through our efforts, the whole question of the flow of air in pipes has of late attracted increased attention, and that reforms in this direction are at hand. Before our articles appeared, however, we understand that several of the mechanical engineering departments of the groups had also begun to investigate the matter; and the net result is likely to be shown in an early increase in the capacities of air pipes in the majority of our mines. We are informed that a paper which Mr. Laschinger is to read to-night before the Transvaal Institute of Mechanical Engineers, will contain a criticism of some of our figures; but that is a form of criticism which we would vastly prefer to no criticism at all.

PNEUMATIC RIVETERS.

The introduction of pneumatic riveters at the Simmer Deep plant construction works is a noteworthy addition to the long list of labor-saving appliances in use on the Rand. While the mechanical engineers of the Consolidated Gold Fields cannot, as far as these fields are concerned, lay claim to have discovered the utility of pneumatic machine tools, as the East Rand Mines have already adopted them, the new departure at the Simmer Deep reflects credit on the enterprise of the engineers responsible. Most satisfactory results, we understand, are being obtained from the use of the riveters on tank work, and the saving is estimated at over 50 per cent. in labor, and upwards of 60 per cent. in cost. The mechanical talent embodied in the invention of pneumatic tools is of the highest order, and is generally regarded as the greatest contribution to methods of machine-shop work made during the closing decade of the nineteenth century. Obviously, exact data bearing on the saving rendered possible are not yet available, but elsewhere, in addition to vastly superior workmanship, a direct economy of as much as 66 per cent. has been obtained from the use of the pneumatic riveter, from which has to be deducted the cost of compressed air, which may be placed at a maximum of 15 per cent.

THE FATAL BENDS

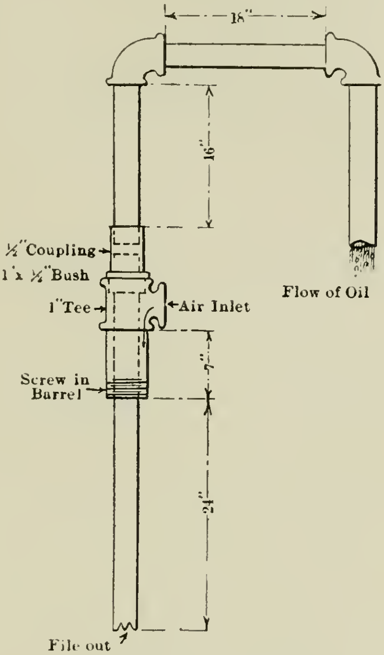
Unusually sad seems to have been the fate of George Harris, a young Englishman, who died the other day in the emergency compressed air hospital connected with the East River tunnels of the Pennsylvania railroad. Harris, who was 29 years old, had been in business in London and is said to have had considerable experience in the sinking of tubes for foundation work. He had been married six months and gave up his business to come to this country, being lured by glowing suggestions of rapid advancement. His testimonials secured him immediate employment as foreman of a night shift in the tunnel. He had been in the country with his young wife only a week when he went on duty. The reports in the daily press seem to suggest that he remained under pressure for an unusually long period. Upon coming out early in the morning he was seized with the "bends," and he was at once placed in the graduated pressure emergency hospital in connection with the tunnel workings. Here he was treated with all the skill procurable, but after a struggle of 30 hours death came and ended all.

PREHEATING AND INTERHEATING COMPRESSED AIR.

Owing to the small size and portability of rock drills preheaters are for this service out of place, but for large hoists and pumps, with high-pressure air, they are always to be recommended. In the operation of the preheater the compressed air passes through a vessel containing heated tubes of sufficient radiating surface for the purpose. These tubes may be heated by a coal, coke or oil fire, but, since smoke contaminates the atmosphere of the mine, steam heating is often both convenient and economical. In an air heater it is possible to utilize steam more efficiently than in the best condensing engine, for both the latent and visible heat of the steam are absorbed by the air and turned into work without frictional losses greater than the motor would suffer with unheated air. With steam heating the only important loss is that due to radiation in the supply pipe from the boilers, and by proper covering this can be made small. In the 500-gallon Dickson pumps, installed in the Anaconda mines at Butte in 1899, the air was successfully heated by steam in both the preheaters and the interheaters for the compound cylinders.—*Engineering and Mining Journal.*

PUMPING OIL BY COMPRESSED AIR

The cut herewith, which we take from *Power,* shows a handy and efficient homemade device used, where a supply of compressed air is available, for pumping or forcing oil out of barrels. A 1-inch tee has a piece of 1-inch pipe 7 inches long screwed into one end of it, the other end of this pipe being screwed into the bung of the barrel, a 1⅛-inch hole being bored in it for this purpose. In the other end of the tee is screwed a 1x½-inch pipe bushing, the bushing having a straight screw thread all through it. A piece of ½-inch pipe 35 inches long with some notches filed across one end is passed through the 1-inch pipe and screwed into the 1 by ½ inch bushing from the inside, the thread on this pipe being cut long enough to screw up through the bushing and take a ½-inch coupling. The delivery pipe may be screwed into the coupling as shown or otherwise as most convenient. An air hose is connected to the side of the tee with a valve for controlling the pressure. When the 1-inch pipe is screwed into the bung the end of the ½-inch pipe comes close to the lower side of the barrel. When the air is admitted it passes down between the ½-inch and the 1-inch pipe and forms a pressure in the barrel which forces the oil up the ½-inch pipe until the barrel is entirely emptied. As only a light pressure is required, the air should be admitted quite carefully or with only a small valve opening.



FOR PUMPING OIL BARRELS.

COAL MINED BY MACHINES IN THE UNITED STATES

The percentage of increase in the production of machine-mined coal in 1905 over 1904 was greater than the percentage of increase in the total production. In 1906 the quantity of machine-mined coal was 15,451,075 short tons greater than in 1905, while the total production of bituminous coal increased 21,534,643 tons, showing that 72 per cent. of the increase in 1906 over 1905 was in the machine-mined product. The statistics also show that the average output for each machine in use increased from 10,258 tons in 1904 to 11,258 tons in 1905, and to 11,638 tons in 1906. The total quantity of coal produced by the use of machines in 1906 was 118,847,527 short tons, as against 103,396,452 short tons in 1905, and 78,606,997 short tons in 1904. The increase in 1906 was 15,451,075 short tons, or 15 per cent. The increase in 1905 over 1904 was 24,789,455 short tons, or 31.5 per cent., while that of 1904 over 1903 was only 623,103 tons, or 0.81 per cent. The number of machines in use increased from 7,663 in 1904 to 9,184 in 1905, and to 10,212 in 1906. The percentage of the machine-mined tonnage to the total production in the States in which machines are used has increased steadily each year. In 1899 this percentage was 23; in 1900 it was 25.15; in 1901, 25.68; in 1902, 27.09; in 1903, 28.18; in 1904, 28.78; in 1905, 33.69; and in 1906, 35.1. Of the 10,212 machines in use in 1906, 5,911, or 58 per cent., were of the pick or puncher type.

ACETYLENE SAFETY-LAMPS*

By L. H. Hodgson.

After numerous experiments, extending over several years, a safe and efficient acetylene safety-lamp has been introduced. It will only be necessary to point out the slight differences of construction as regards the treatment of the calcium carbide in the benzine safety-lamp. The oil-vessel becomes the receptacle for the calcium carbide, and is filled two-thirds full, thus allowing one-third for the expansion of the carbide when saturated with water. The upper vessel or the water-container is fitted with a filling aperature, an internal friction-igniter operated from the outside, and a water-and-gas shut-off, which comes into action separately, that is, when the outside lever is turned 45 degrees from left to right, the water is shut off and no further generation of gas takes place, but the lamp continues to burn and the residue is consumed in a few minutes; but should the lamp need to be instantly extinguished, the lever is turned the full 90 degrees, or as far as the lever will go. The gas thus inclosed gradually escapes through the by-pass. A safety-valve or by-pass is placed adjacent to the burner. Should the lamp be required immediately after it is extinguished, it is advisable to allow, say, five seconds to elapse before bringing the internal friction-igniter into operation, as the pent-up gas issues with extra velocity, producing, when lighted, a slight puff, which is detrimental to the wire-gauzes. The attachment of the two vessels is very simple: two staples on the side of the water-vessel are brought under two projecting buttons fitted on the carbide-container, and the vessels are firmly connected by pressing down the shank. A gas-tight joint is made with the aid of an india-rubber ring, inserted in a groove running round the circumference of the water-vessel.

The lamp has a flame which is of 10 candle-power. The flame is capable of being reduced at will, and, with 1 per cent. of fire-damp, there is a clearly defined blue cap surrounded by a greenish-yellow halo; while, with 3¾ per cent. of fire-damp, there is a well defined cone, with a hemispherical base, of a clear, luminous, greenish-yellow tint.

The period of burning varies from 6 to 12 hours, according to the size of the lamp. The carbide-chamber, for 6 hours' burning, when three-quarters full, contains 4 ounces. Carbide may be purchased in quantities at 6 cents per pound, and consequently the cost will be 0.25 cents per hour, per 10 candle-power, or 7.5 cents for five shifts of six hours.

The large acteylene safety-lamp, of 60 candle-power, is fitted with a water shut-off, which considerably assists in the economical burning of the lamp, as hitherto, it has been necessary to regulate the charge of calcium carbide to the time that the lamp is required to burn. The carbide-chamber, for 20 hours' burning, is filled with 3¼ pounds. The cost of burning is slightly less than 1 cent, or 0.016 cents per candle-power per hour.

COMBINED PUMP AND AIR LIFT

The following, signed "Chief Engineer," Washington, D. C., comes from a recent issue of *Power:*

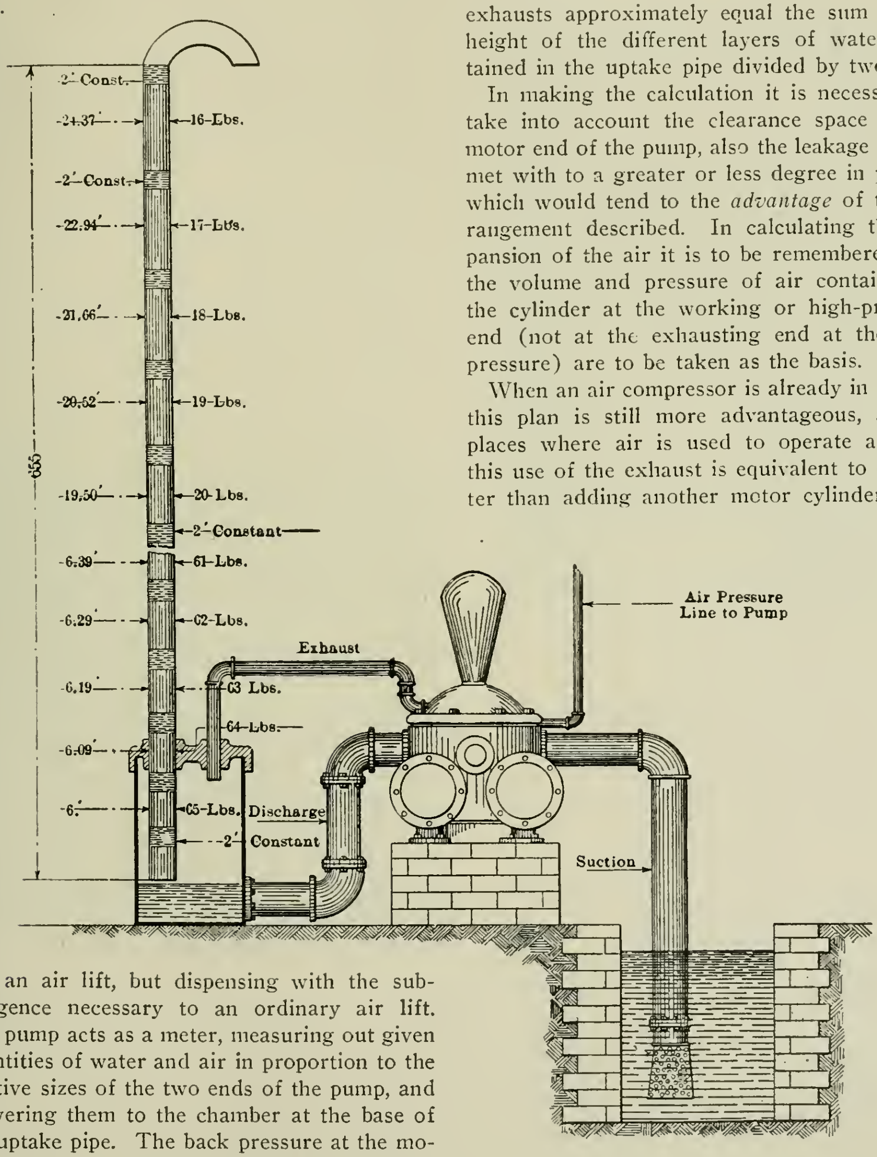
The peculiar condition suggesting this arrangement was the need of water on the top of a mountain some 700 feet above the source of supply, a spring at the base of the mountain giving about ten gallons a minute. The distance and the difficulty in getting to and from the spring made it undesirable to locate a gasoline engine and geared pump at that point. Besides, the flow was so limited that to keep a man there for the length of time necessary to get enough water pumped up the hill would make the water very expensive. The operating conditions would be severe, too, for a plant located in an out of the way place, the pump working against something like 350 pounds pressure. The lower one-third, at least, of the piping would have to be extra heavy and well put together.

The installation adopted consists of a gasoline engine-driven air compressor outfit located on the top of the mountain, near the residence or barn, where the cost of equipment and attendance is minimized. The air pipe from the compressor is connected to an ordinary direct-acting steam pump (duplex or single) located at the spring, the air taking the place of steam (this arrangement is common in mines), but instead of exhausting into the atmosphere, the exhaust is led into the top of the chamber shown, into which the pump also discharges the water at the bottom.

When in operation the water and air ascend in the uptake pipe in alternate layers exactly like an air lift, but dispensing with the submergence necessary to an ordinary air lift. The pump acts as a meter, measuring out given quantities of water and air in proportion to the relative sizes of the two ends of the pump, and delivering them to the chamber at the base of the uptake pipe. The back pressure at the motor end of the pump is identical with the back pressure in the high-pressure cylinder of a compound pump or engine, but instead of completing the expansion in another engine cylinder it expands in the uptake pipe, as it travels upward between two layers or pistons of water, in proportion to the total number of feet of water above it. The space required by the air in the uptake pipe reduces the number of feet of water contained in the pipe, so that the pressure against which the pump works and the back pressure against which the motor end exhausts approximately equal the sum of the height of the different layers of water contained in the uptake pipe divided by two.

In making the calculation it is necessary to take into account the clearance space in the motor end of the pump, also the leakage always met with to a greater or less degree in pumps, which would tend to the *advantage* of the arrangement described. In calculating the expansion of the air it is to be remembered that the volume and pressure of air contained in the cylinder at the working or high-pressure end (not at the exhausting end at the back pressure) are to be taken as the basis.

When an air compressor is already in service this plan is still more advantageous, and in places where air is used to operate a pump this use of the exhaust is equivalent to or better than adding another motor cylinder, i. e.,



COMBINED PUMP AND AIR LIFT.

using a compound pump. It is superior to the air displacement system of pumping and in many places superior to the air lift system.

A COAL DUST PHENOMENON

At a recent meeting of the Midland Institue of Mining, Civil and Mechanical Engineers, held at Doncaster, England, Mr. J. Neal read a paper describing the ignition of coal dust in the Beeston seam at the Middleton Colliery. The seam was a very dry one, and dust accumulated very rapidly. Early in September last a deputy had opened a safety lamp at the lamp station. A train of full tubs, drawn by a pony, was passing, and raised a considerable quantity of dust. Just before the train reached the lamp station the deputy removed part of the burning "snuff" from the wick of the lamp, and it fell harmlessly to the floor. As soon as the train had passed he knocked away the remaining portion of the snuff, and as this fell to the floor there was an ignition of the coal dust. The flame rose to a height of about 2¾ feet, and spreading over a width of 3 feet, followed the train with a peculiar rolling motion, apparently corresponding with the successive clouds of dust raised, making a peculiar hissing sound. The train stopped about 45 feet beyond the lamp station, and when the flame reached the last tub it ascended to the roof, returned along the upper portion of the roadway, and finally extinguished itself within 3 feet or so of the point of ignition. The color of the flame was described as being similar to that of a candle or oil lamp. Mr. Neal observed that mining engineers had thought that nothing short of an ignition or an explosion of gas, or gas and dust, could cause a coal dust explosion, and that was his opinion until this incident occurred.

VACUUM CLEANING OF RAILROAD CARS

The Chicago, Milwaukee & St. Paul Railway in a series of striking advertisements in the November magazines is calling itself "The Sanitary Way," and the reason therefor is the recent installation at the "Milwaukee" yards in Chicago of a vacuum equipment for cleaning the upholstery, carpets, curtains and bedding. "By its tremendous suction force," read the railroad's advertisements, "it removes dust, dirt, grit and germs as no other method can." The vacuum system was adopted after a series of tests lasting for several months. After cars had been blown by compressed air they were "vacuumized" and the dirt sucked out was weighed, with the result that from 1 to 2½ pounds of dirt could be "vacuumized" out of the plush and carpets. A thorough "vacuumizing" once every third or fourth trip keeps the car in better condition than if it were "beaten" or blown every trip. A rapid dusting on intervening trips is enough to keep the dust from accumulating. The labor saving nature of the device is shown by the fact that the first machine installed at the Western avenue yards of the C. M. & St. P. enabled the yard foreman to cut down his payroll $100 a month.

Under the aero air cleaning system, as it is called, the vacuum is produced by means of a compressed air aspirator, drawing its power from the air pipes which are laid through the yards for testing brakes. When the workman using the vacuum apparatus passes the cleaning tool or nozzle over the surface of a cushion or carpet the dirt is quickly sucked through the vacuum hose into the dust tank. This tank is mounted on wheels and is readily brought alongside the car to be cleaned. The aspirator is attached at one side of the tank. Inside is a separator which collects all the dirt. The cleaning is all done inside the car and without raising any dust.

DRYING

Things to be dried must contain moisture, and the process of drying is the vaporization of this moisture and its transfer into surrounding space. If the air filling this space is confined it becomes saturated and the drying stops. If the moisture is to be continually carried away the air which is the conveyor must be kept constantly moving. Heat is merely a useful accessory to decrease the time of drying by increasing both the rate of evaporation and the absorbent capacity of the air. Air is not necessary and the space may be a vacuum; under either condition a certain space will take up a stated weight of vapor. When vapor is diffused in air the vapor molecules occupy their own displacement in addition to the space occupied by the dry air. Less air is contained in a given space if saturated with vapor than if dry, and yet the specific gravity of the moist air will be lower than that of dry air of the same temperature, because vapor is lighter than air at the same pressure and temperature. If a certain space is saturated with vapor when at a certain temperature, an increase of temperature will increase the capacity for moisture, but if the temperature is lowered some of the vapor will be deposited. The temperature at which deposition begins, is called the "dew point," and it depends upon the initial degree of saturation of the given space, the less the relative saturation the lower the dew point. Heat is such a valuable agent in the drying process because it changes the capacity of air for absorption, the amount of vapor a given space will contain increasing rapidly with the rise in temperature.

THE SOBLIK PNEUMATIC TYPEWRITER

The typewriter shown in the half-tones, carrying the name of the inventor, has been described recently in *La Nature,* Paris, by Dr. Alfred Gradenwitz. The operator touches the keys to indicate the letters, but no appreciable force is required, and the fatiguing work of protracted operating is annihilated by the pneumatic devices which supply the necessary force.

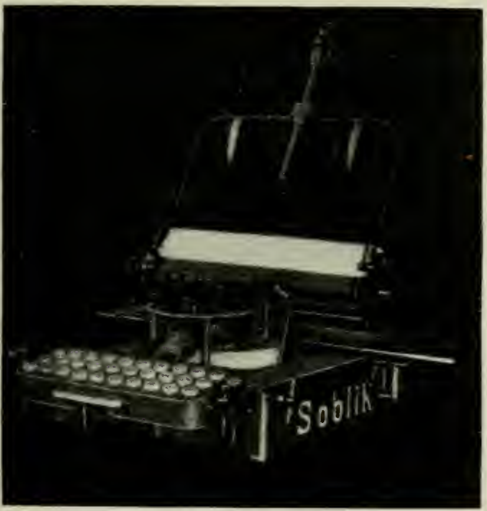


FIG. 1. THE SOBLIK AUOTMATIC TYPEWRITER.

The keyboard of the machine has several rows of buttons with a corresponding opening for each in the cover of a rectangular air box, each opening connected by a small tube with the center of the machine where the type wheel is placed. The rim of this wheel, carrying characters in raised type, is rotated until the letter indicated is brought into position, and the impression is made by thrusting out the letter to strike the surface of the paper. The pneumatic action gives a uniform pressure for each letter independent of the action of the operator, and this pressure may be adjusted by the movement of a lever according to the requirements of the work in hand. When a large number of carbon copies are being made the operator has no more effort to make than when a single impression is made. By pressing other buttons the carriage is brought back to the beginning of the line and the spacing for the next line is adjusted.

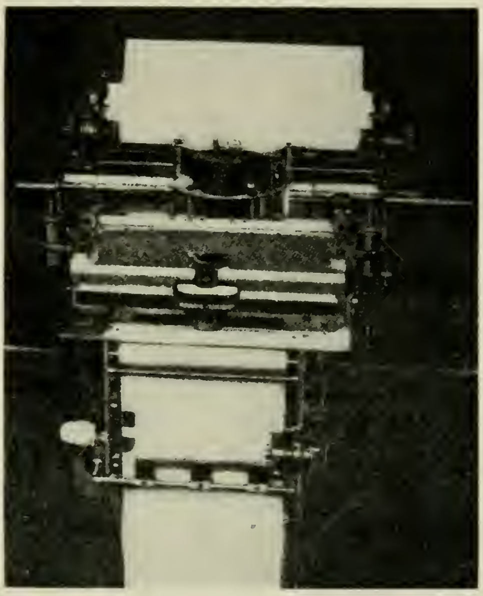


FIG. 2. PNEUMATIC TYPEWRITER WITH AUTOMATIC MULTIPLIER.

In this machine several buttons may be pressed at once and the letters will be correctly printed, provided they follow in alphabetical order. Syllables or entire words may thus be printed by a single touch.

The inking of the characters is similar in operation to that of a printing press. The ink may be changed at once without changing the types or any risk of soiling the paper with too much ink.

The air used to operate the machine is compressed by a minute electrically operated compressor. The machine may even be run by blowing into the tube.

The types are rather pressed against the paper instead of striking it, so that there is no appreciable noise from the operation. The writing is always visible. The weight of the machine is about 15½ pounds and the dimensions are 12x10x6 inches. An automatic multiplier, seen in Fig. 2, may be used with the machine. This is below the keyboard and produces a perforated pattern upon another sheet of paper. When the writing is finished the perforated record may be used to reproduce as many copies as may be desired.

BEGINNINGS OF SUCCESS IN FLIGHT

I was lucky enough to study at leisure the trial flights of Henry Farman for winning the $10,000 prize which he earned so well. He was to fly on his aeroplane a half-kilometre (one-third of a mile), then turn a goal and return to the starting point—all without once touching ground. The length of this irregular oval around which he took his course in mid-air was full three-quarters of a mile; and, since his victory, out of pure lightness of heart, at a motor working well, he has made a circular flight three times as long. Not enough has been said of the mere look of man and machine as they "plane" against the sky; for a new verb is needed to describe the motion.

It is like nothing else ever seen before. It is not even like Santos Dumont's little dirigible baloon—the "No. 9," which carried him back and forth so easily from place to place in the Bois de Boulogne, like an automobile running through the air. Small as its gas bag was, the "No. 9," like all balloons, kept the look of being suspended by something, held up in the air as it glided about. On the other hand, the biggest kite shows always by its movements that a string is holding it down. Farman's aeroplane moves like neither the one nor the other; it does not even resemble a giant bird cutting through space, any more than an automobile resembles a horse.

It is a vast human structure, as evidently a machine as a steam engine, with its spread of box-like cells and whirring motor and place for the pilot in the middle. Its flight through the air in long rising and falling curves, as the motor varies its power, is graceful beyond measure, but thoroughly human—just such a mechanical grace as that of a motor launch over a broad expanse of water.

Soon the sight will become as common as any other; for men have found what Clerk Maxwell called in electricity the "go" of the thing. Farman knows now just how many pounds' weight his motor will take up into the air and how long a flight. The motor's the thing.

THE KEY TO SUCCESS.

All these steady advances, however slow, were made possible by Santos Dumont's daring in hitching a petroleum motor to a balloon. I was also lucky enough to follow his very first experiments, only ten years ago. He had to face the entreaties of anxious friends and the open scorn of professional men of the air. He went on his way, year after year, undiscouraged by repeated failures; but he made of each failure a trial experiment of his principle, which he was sure was right. Thanks to his experiments, we have now two branches of an already practical industry—petroleum as a means of transport through the air. There are the great motor balloons for war; and there are these machines like Farman's, without any gas to help them, flying of themselves by the propulsion of a petroleum motor. The world has moved within that space of ten years; but human nature—in critics, in the crowd always too much in a hurry, and luckily in mad or inspired inventors paying no attention to either—remains a constant quantity.

No fair man can doubt that these flying machines will be made practical—little by little, like everything that comes to stay. They are here now for learning and sport. Soon rich amateurs will use them for their luxurious pleasure. Last will come their plain, everyday use when time and constant experiments shall have made known their possibilities. Even we, who by this vision splendid are on our way attended, may live to perceive it die away and fade into the light of common day. So was it with our prehistoric grandfathers when they saw the first wheel turning round an axle and rolling, instead of grinding its way, along the ground. So was it with those who looked on the first man that girdled his robustious heart with triple brass enough to embark in a frail raft on the cruel sea. We have slipped a notch in Time; and it is worth noting before it is forgotten.

PROGRESSIVE PRIZES.

The prizes which stimulate to experiments like Farman's have been graduated here in

France with great good sense. Instead of asking a brand-new, still uncertain invention to be put in competition with motor locomotion long practised on terra firma, the first prize was for flight in a straight line for a distance long enough to prevent skeptics saying: "Pooh! that was only a great bound in the air." Santos Dumont won this first prize last autumn, just as he was the first—publicly—to steer a balloon.

Then M. Deutsch (the same who gave the $20,000 won by Santos by steering his balloon from Saint-Cloud round the Eiffel Tower and back) and M. Archdeacon offered the prize which Farman has just won. The task was to fly a moderate distance and turn in the air and return to the starting point.

Now M. Armengaud, an engineer of international reputation and an authority on aeronautics, offers $2,000 to the man who will fly on his aeroplane for one-quarter of an hour without touching ground.

First, to fly at all; then, to steer the flight; now, to prolong the flight—these are the natural beginnings, even with a bird learning to fly. In due time will come long distance flights; starting and landing and steering matches; then other exercises of skill; and, the crown of all, as with the horse, with automobiles, with transatlantics—races. This is a practical order of things, instead of summoning the inventor first off to do everything at once or for ever after to hold his peace.—S. D. in *Evening Post* (New York).

CHLORIDE OF CALCIUM INSTEAD OF SALT

Chloride of calcium is being used more and more instead of salt in refrigeration, and those who substitute it for common salt will never go back to the other. Salt always contains a large amount of impurities, and its iron-destroying effect makes it rather costly in the end. It should be borne in mind that when a pipe is attacked from both sides its life will be rather short. This is also the case with the tanks containing the salt brine, and with pumps for handling it. This, as well as the great majority of other troubles that are experienced in using salt brine, is avoided when using chloride of calcium. It seems to pass through the pipes with less friction, and parts which were in use for a long time, showed upon removal that no corrosive action had taken place inside. Chloride of calcium also has a much lower freezing point than common salt brine, and is therefore better suited for places where a low temperature is required.—*The American Brewers' Review.*

NEW PUBLICATIONS

Illustrated Catalog of Steam Pumps No. 35, A. S. Cameron Steam Pump Works, New York, 158 pages 6 by 9 inches. This is an excellent specimen of a standard catalog. It gives full information concerning the various styles and sizes of pumps made and the special features and adaptabilities of each, with so much incidental information that the single page index might well have been doubled, even if the table of areas of circles (what catalog is without it) had been omitted.

NOTES

In 1906 the New York Edison Company, in the regular course of business, sold from its plant scrap to the value of about $200,000. The material included 632,000 pounds of copper, 359,000 pounds of lead, 71,000 pounds of mixed metals and approximately 500 tons of iron.

The rule adopted by the A. L. A. M. for estimating the horse-power of gasoline engines is to square the cylinder diameter in inches and divide the product by 2.5, which gives the horse-power per cylinder.

In drilling with piston rock drills a high pressure gives a stronger withdrawing force on the bit and tends to prevent sticking in fissured ground. In hard, tough ground, like specular hematite or certain intrusives, a high air pressure is necessary if it is desired to strike a blow, severe enough to cut the rock, with a light portable machine. In a certain mine, using 40 drills in hard and fissured ground the rock broken per machine was increased about 20 per cent. by the simple expedient of advancing the air pressure from 75 to 100 pounds.

A pneumatic jack has been designed to help in starting a large motor generator of the Edison Illuminating Company at Detroit. It comprises an air cylinder with a piston connected to an arm, this arm having a pawl engaging a ratchet on the armature shaft. The idea is for this jack to give the armature a single impulse or kick to overcome the standing bearing friction, which is considerably higher than the running friction of any plain bearing, and also to overcome some of the inertia of the rotating parts. It is found by the use of this device that the machine can be started with a maximum current of 500 or 600 amperes, as against 1,500 amperes when it is started in the usual manner from rest.

Since a machine will drive rivets as fast as they are fed to it, the chief cost is that of handling the work. This varies with the class of work, heavy and bulky work being, of course, harder to handle. Assuming $4.50 a day for the labor, exclusive of the heater, if a machine drives some 700 or 800 rivets a day the cost for labor, power and general charges will be from ⅝ to ¾ cent per rivet. Pneumatic hammer rivets in ordinary shop work will cost hardly less than 1½ cents per rivet for similar charges. Assuming only ½ cent saved per rivet, there is $1,000 or $1,200 saved per year. A much greater saving will generally result, for if double the machine rivets are driven per day the cost per rivet is practically cut in half.

Liquid air promoters are endeavoring to interest capital in the establishing of liquid air producing plants, as at Richmond, Va., where demonstrations of the interesting properties of this exceedingly cold but perfectly dry liquid were given. The claims of the promoters as published in the local papers and widely copied are, however, misleading. The enormous saving claimed by substituting liquid air for ice in refrigerator cars is still a matter that needs to be demonstrated. The statement that the promoters were making liquid air at a cost of $44 for 140 gallons also is misleading. That would be over thirty cents per gallon, while Mr. Bobrick at Los Angeles, Cal., has been making it for a number of years at less than ten cents per gallon, and claims he can make it for one cent per gallon and store it for nearly thirty days.—*Ice and Refrigeration.*

Dr. Joseph A. Holmes, in Bulletin 333 of the U. S. Geological Survey, says that experience in the deeper and more dangerous coal mines of Belgium and other countries not only indicates that American mine accidents may be reduced to less than a third their present number, but also gives promise of their practical prevention. The coal mining methods of America are less safe than those of any other country. Over two thousand men were killed and five thousand more were injured in our collieries during 1906. This was 3.4 men killed for every thousand employed. In Belgium in 1906 the number was 0.94, in Great Britain it was 1.29, in France it was 0.84 in 1905, and in Prussia it was 1.8 in 1904. The number of American coal miners killed and injured in 1906 by different causes is stated as follows: Gas and dust explosions, 228 killed and 307 injured; powder explosions, 80 and 215; falls of roof and coal, 1,008 and 1,863; other causes, 732 and 2,192. What makes these figures more shocking is Dr. Holmes' further statement that in no other country in the world are the natural conditions so favorable for the safe extraction of coal as in the United States.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JANUARY 7.

875,787. FLYING OR AIR CAR. Selden A. Day, Paris, France.

875,869. ROCK-DRILL. Rolland S. Trott, Denver, Colo.

875,942. ACETYLENE-LAMP AND LIGHTING DEVICE FOR AUTOMOBILES AND OTHER VEHICLES. Svend M. Meyer, New York, N. Y.

875,957. THERMOSTAT. Olaf Saugstad, Plainfield, N. J.

875,958. VALVE FOR FLUID-PRESSURE BRAKES. William H. Sauvage, New York, N. Y.

876,066. AUTOMATIC FLUID-PRESSURE REGULATOR. Archie Klever, Hannibal, Mo.

876,068. RIVET-CUTTER AND PUNCH. Conrad H. Lau, Renova, Pa.

876,119. ACETYLENE-GAS GENERATOR. William J. Walsh, Ferris, Tex.

876,125. FYLING-MACHINE. Frank Wondra, Schenectady, N. Y.

JANUARY 14.

876,359. PRESSURE-REGULATOR FOR COMPRESSED-GAS PLANTS. Louis Karger, Ehrenfeld, Germany.

876,371. PNEUMATIC BRUSH. Frank J. Matchette and Charles Moukos, Milwaukee, Wis.

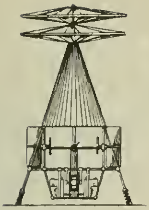
876,374. HOT-AIR ENGINE. Alphonse Mayr and John Wallace, Bombay, India.

876,422. ELASTIC-FLUID TURBINE. Jan Zvonicek, Brünn, Austria-Hungary.

876,426. PNEUMATIC SUSPENSION DECIVE FOR VEHICLE-BODIES. George W. Bell, Liverpool, England.

876,460. STARTING MECHANISM FOR INTERNAL-COMBUSTION ENGINES. Howard A. Johnson, Toronto, Ontario, Canada.

In an internal combustion motor the combination of a storage air tank; a second tank; a pipe connecting the two; a stop cock in said pipe; a pipe connecting the second tank with the cylinder of the engine; a pressure limiting valve in said pipe; and a stop cock between the pressure limiting valve and the second tank, substantially as described.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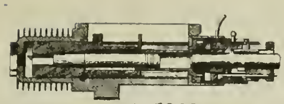
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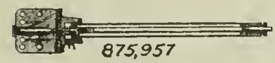
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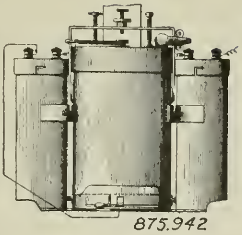
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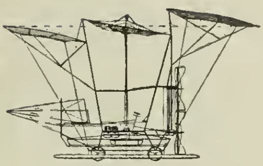
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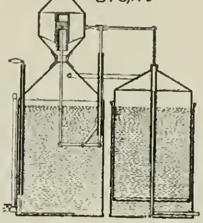
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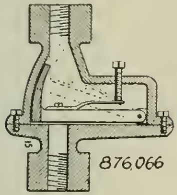
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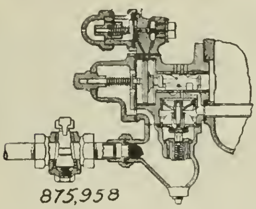
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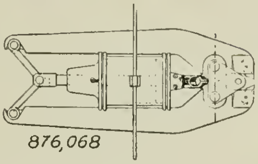

876,068

PNETMATIC PATENTS JANUARY 7.

876,757. APPARATUS FOR PRESERVING EGGS. Hans J. Wintherlich, Omaha, Nebr.

In an apparatus for preserving eggs, the combination of a receptacle, means for supporting eggs therein, a vacuum producing means connected with the receptacle, means for subjecting the receptacle and contents to heat for opening the pores of the eggs and killing the germs, and separate means for supplying antiseptic and sealing solutions to the receptacle.

876,827. CAISSON CONSTRUCTION. Alexander Z. McLeod, New York, N. Y.

876,848. PUMP OPERATED BY COMPRESSED AIR. Danvill W. Starrett, San Francisco, Cal.

876,849.— PUMP OPERATED BY COMPRESSED AIR. Danvill W. Starrett, San Francisco, Cal.

876,859. PNEUMATIC CARRIER. Major R. Collins, Indianapolis, Ind.

JANUARY 21.

877,043. VALVE OPERATED BY AIR. James Bowes, Caldwell, N. J.

877,102. PRESSURE AND SUCTION BLOWER. William J. Magee, St. Louis, Mo.

877,142. MEANS FOR INCREASING AND PROMOTING THE COMBUSTION OF FUEL. George R. Torrey, Washington, D. C.

In an apparatus of the character described, a furnace, a fire-chamber, a bridge-wall, a vortex chamber within the bridge-wall for giving a circular, centrifugal action to steam and air, and means for forcing said steam and air into and through the fire chamber of the furnace.

877,162. APPARATUS FOR CONSUMING GAS. Frank W. Beardsley, New York, N. Y.

877,203. PNEUMATIC MUSICAL INSTRUMENT. Eugene de Kleist, North Tonawanda, N. Y.

877,234. ACETYLENE-GENERATOR. Samuel W. Rushmore, Plainfield, N. J.

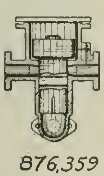
877,308. PNEUMATIC CAISSON. Oliver C. Edwards, Jr., Rensselaer, N. Y.

877,369. ELECTROPNEUMATIC MACHINE. William K. Rankin, Philadelphia, Pa.

877,387. SAFETY-SPRING FOR STEAM AND COMPRESSED-AIR HAMMERS. Willis F. Walker, York, Pa.

877,447. PROCESS FOR THE PRODUCTION OF PURE NITRIC ACID. Harry Pauling, Gelsenkirchen, Germany.

The herein described process, consisting in subjecting atmospheric air to the action of electrical discharges, mixing the nitrogenous gases, thus formed, with water or aqueous vapor while the said gases have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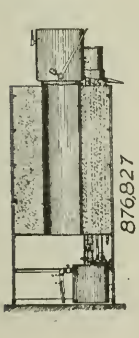
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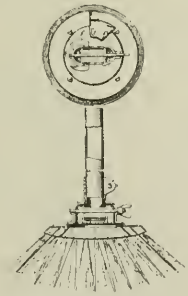
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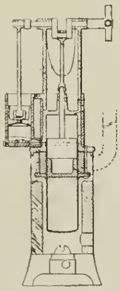
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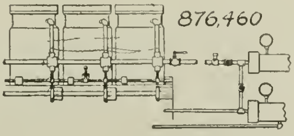
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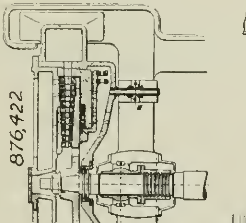
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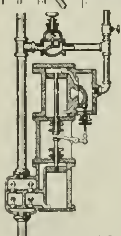
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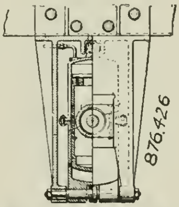
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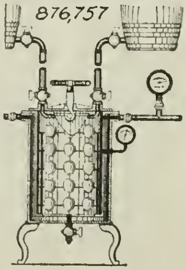
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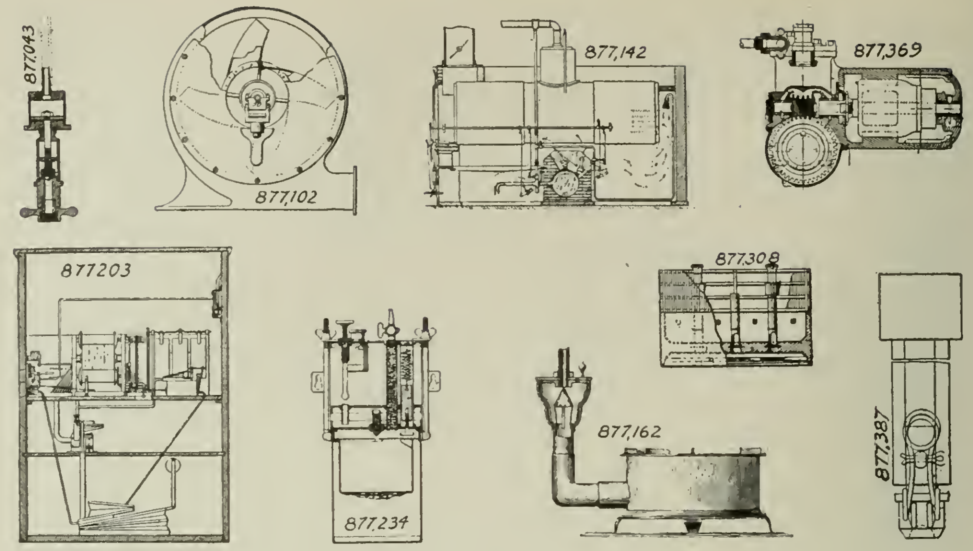
PNEUMATIC PATENTS JANUARY 14.

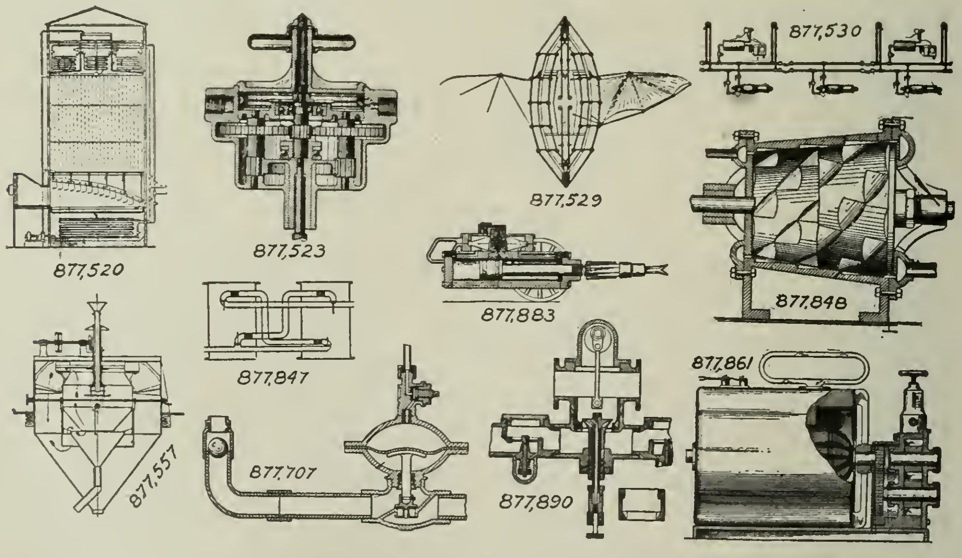


PNEUMATIC PATENTS JANUARY 21.

a minimum temperature of 200 degrees C., and cooling down the mixture, as set forth.

JANUARY 28.

877,520. FLUID-COOLING APPARATUS. PAUL SCHMALTZ, New York, N. Y.
877,523. PNEUMATIC DRILL. JOHN W. SMITH, Philadelphia, Pa.
877,529. AIR-SHIP. PETER T. TKATZSCHENKO, Schenectady, N. Y.
877,530. AIR-BRAKE. WALTER V. TURNER, Wilmerding, Pa.
877,557. AIR-SEPARATOR. GEORGE S. EMERICK, Nazareth, Pa.
877,707. AUTOMATIC SPRINKLER SYSTEM. JAMES FIDDES and JOHN F. WATT, Aberdeen, Scotland.
877,847. FLUID-PRESSURE ENGINE. HUGO LENTZ, Hallensee, Germany, and CHARLES BELLENS, Neuilly-sur-Seine, France.
877,848. FLUID-PRESSURE TURBINE. BENJAMIN E. LEWIS, Palouse, Wash.
877,861. PORTABLE TIRE-INFLATER. JOHN W. RADU, Rochester, N. Y.
877,883. PNEUMATIC MINING-MACHINE. WILLIAM B. BUTTS, New Philadelphia, Ohio.
877,890. VAPORIZER. GEORGE H. GERBER and ALFRED WEILAND, Reading, Pa.



PNEUMATIC PATENTS JANUARY 28.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. XIII APRIL, 1908 No. 4

THE MELTING AND BURNING OF IRON IN COMPRESSED AIR

There are current in the technical press of the day accounts of many entirely unrelated developements in the line indicated by the above title. That iron will burn fiercely in oxygen was frequently shown in laboratory and lecture room experiments two or three generations ago. The burning of a watch spring in a jar of oxygen is in all the old school books of physics or natural philosophy. The commercial production of oxygen in unlimited quantities and at low prices is leading now to its extensive and growing employment in our most important industries.

BURNING OUT BLAST FURNACE TAP HOLES.

Robert Grimshaw in the *Engineering and Mining Journal* describes the process invented by Dr. Menne, of Krenztal in Westpalia, of clearing the tap holes of blast furnaces, using compressed oxygen as the agent with the aid also of hydrogen as a starter. "The hydrogen is first turned on when the gas is ignited, the oxygen control valve is opened, the pressure being well throttled down until the iron is white hot. Then the pressure of the oxygen is raised until the cast iron commences to burn, which is indicated by strong sparking. The oxygen pressure is again raised, this time to about 450 lb. per sq. in., and the hydrogen is shut off. From this point on, the fuel is iron, instead of hydrogen, and consequently there is a greater development of heat.

Hydrogen and oxygen alone would not melt through the solidified mass, because the great volume of gases necessary would cause excessive loss of heat by radiation and conduction. One kilogram of hydrogen develops in combustion with oxygen about 13,057 calories, while the same weight of iron develops only 748. But a given weight of hydrogen takes up 87,234 times more room than the same weight of iron. Thus one volume of iron, burned in oxygen, develops 87,234 x 748 ÷ 13,057 = 5,012 times as much heat as the same volume of hydrogen under the same conditions.

"In burning the iron the heat developed is concentrated in a small space; and this accounts for the enormous temperature and the rapid action of the combustion on the frozen tap hole. The stream of gas not only melts the iron, but also blows it away from the hole. A slag hole or a tuyere opening an inch or so in diameter may be freed from solid iron without injuring the walls, which are cooled by the action of the stream of gas under the high pressure employed. When hydrogen is not available, generator gas or ordinary illuminating gas may be used to start the operation."

COMPRESSED AIR FOR WELDING.

In the Bessemer process compressed air alone is blown up through a mass of molten iron, raising its temperature with great rapidity, burning out first all the carbon and then, if the operation is continued, the iron also, affording throughout one of the most brilliant pyrotechnic displays ever produced. While this process has been widely and constantly employed for forty or fifty years, most suggestive as it has been of other possibilities, it seems to be only lately coming to be realized that a jet of compressed air with sufficient pressure to give it the required velocity can alone supply sufficient oxygen to cause red hot iron to burn. There are indications, however, that the air jet will soon be in familiar and frequent use in every blacksmith shop, or, what is now nearly the same thing, in every blacksmith shop in which a supply of compressed air is maintained.

W. C. Whelan, Foreman Blacksmith, Kansas City, writes as follows:

"I took a piece of two-inch round iron,

brought the end to a low welding heat, and by turning on about eighteen-pounds pressure, burned off three inches of the iron. I then brought two pieces of two-inch round iron to a very low welding heat (a heat which could not be welded successfully in the ordinary way), and by applying the air made a successful butt weld, which we bent back and forth over the anvil without a fracture developing. After testing in other ways, I am convinced that all small hammers, forging machines, flue-welding machines, and also all heavy fires, where V-welds are made in frames, or, in fact, any fire where a clean, safe weld is required, should be equipped with air, either by a small, round nozzle, or a flat nozzle if the work done is on a wide piece. I believe that in welding frames on engine or anvil this process will hold the heat until the work is completed, and all dirt and foreign substances are eliminated."

Mr. Geo. A. Hortline, Blacksmith Foreman at the Collinwood shops of the L. S. & M. S. Ry., writes as follows to the *Railway Journal:*

One of the small kinks in the Collinwood shops that has helped us in successful welding in the forging machine, is a compressed air jet used for bringing two pieces of iron to a point of fusion immediately before the stroke of the forging machine.

While some blacksmiths may be familiar with this method, we find it is new with many others. A very interesting experiment to demonstrate the possibilities with this method is to heat a bar of one inch or one and one-fourth inch iron on the end for five or six inches, then blow a stream of air against the end of the bar parallel with its length; a beautiful display of fireworks will be the result, the temperature of the bar will be raised to a point of fusion and the bar will melt away as in the foundry cupola.

We have been quite successful in making large crank pin nuts with the aid of this method. A piece of bar iron 2 x 7/8 in. is rounded up under the hammer, each end of the bar being sheared to an angle of 45 degrees so as to form a lap. These pieces of iron are heated in an oil furnace, placed between the dies of the forging machine, a jet of air is blown against the two ends, which cleans out all dirt and scale and raises the temperature of the metal to a welding heat, one stroke of the machine insuring a perfect weld with clean metal.

The same method is used in welding the cross bar on our clinker hooks for locomotive service. The end of the long rod and a short bar are both heated to a welding heat in our oil furnace; the long rod is butted against the short piece and placed between the dies, where it comes in contact with the jet of compressed air. which blows out all scale and dirt, bringing the two pieces to a perfect welding heat and one stroke of the machine completes the weld and upsets the metal so as to strengthen the hook at the point of intersection.

In reparing and welding broken spokes or rims in steel driving wheels we think the compressed air jet is indispensable. Some of the wheels are very difficult to handle owing to the counterbalance, and it is very difficult to get a wheel from the fire to the anvil without losing the heat. By using the compressed air jet it is possible to revive the heat and the parts to be welded will retain a welding heat after the operation is complete. In welding spokes in steel wheels we use the "V" weld. The heat is taken on a side fire and just before the piece is welded into the spoke the compressed air jet is brought in contact with the hot metal, keeping the temperature of the metal up to a welding heat until the operation is completed. Care must be taken, however, in applying this compressed air jet, as it would be possible to burn a spoke in two if held at one point too long.

TESTING STEEL BY ITS SPARKS.

Another phase of the combustion of iron in air is presented in an interesting article which recently appeared in the *American Machinist,* in which the writer suggested the sparking of steel when ground on an emery wheel or when filings are thrown into a flame as a means of determinining the character of the steel. "In the former case," the writer says, "there must be enough strength to resist wear or cutting in order to heat the detached particles, and this heat must be intense enough to cause oxidation, while in the latter case, the metal must be subject to combustion at the temperature of the flame, without volatilization, before any amount of light is produced. Now the action of grinding or of a candle flame cannot produce heat enough to volatilize iron or steel, but the heat imparted is ample to cause chemical combination between the oxygen of the air and the iron, which in the process of combustion causes heat of sufficient intensity to ignite the carbon contained in the iron and especially steel.

"This fact is beautifully demonstrated by the iron torch, shown in Fig. 1. By heating a bar of iron to a welding heat and then holding it in a stronge air blast, it will at once begin to boil and sizzle, emitting a dazzling bluish-white light. This may be maintained for hours without any source of heat, except that caused by the combustion of the iron. Beginning with let us say slag iron, which is almost free from carbon, the spark test will usually give straight lines, which become broader and more luminous some distance (not over a few inches) from their source, and then disappear as they started (see 1 of Fig. 2). This peculiarity is probably due to the action of the oxygen on the heated particles requiring some time to act. This effect is at its maximum when spark streak appears broadest and whitest, and would continue so, but for the reason that the fuel supply is soon exhausted.

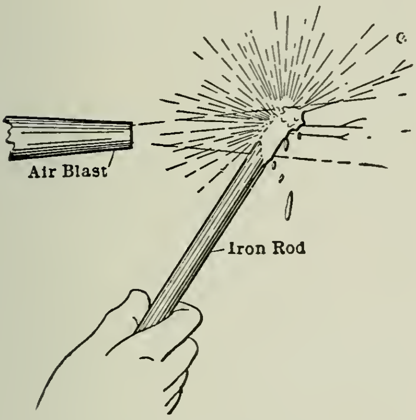


FIG. 1—BURNING IRON IN THE AIR BLAST.

"By adding a very small percentage of carbon to iron the effect is at once noticeable by a division or forking of the luminous streaks, as in 2 of Fig. 2. This is owing to the presence of the carbon, which is only acted on by the maximum heat of the iron spark, and which then burns explosively, causing a break in the original heavy line. By adding more and more carbon to the steel, the iron lines become less and less conspicuous, and the star-like explosions not only become extremely profuse, but their rays often divide again and subdivide, causing a beautiful display of curves and figures, as in 3. In this instance it should be stated that the iron and carbon have been so united that they are most easily attacked by the oxygen, and hence the great danger of burning tool steel in the process of forging. This readiness to burn may be considerably reduced by the addition of a more refractive metal as tungsten or molybdenum. The former alloy shows not only anti-rusting qualities but also can endure incandescent heat without scaling or burning. The temper is thus not drawn so easily and hence the name, high-speed steel.

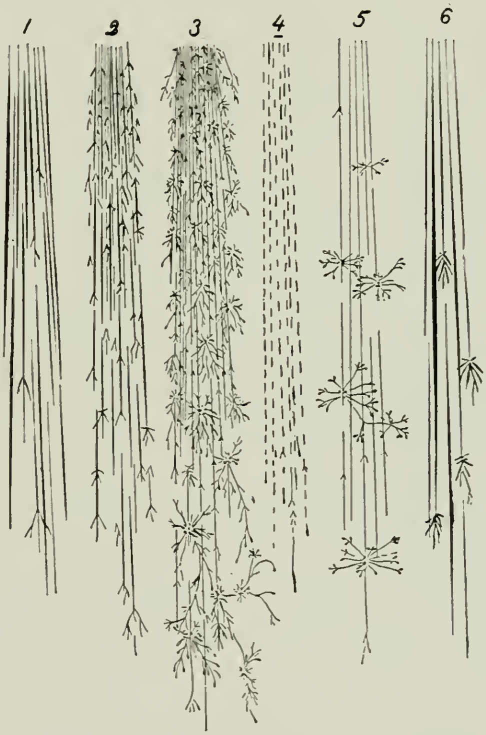


FIG. 2.—TESTING BY THE SPARKS.

"In the spark test these peculiarities are shown as indicated by 4 and 6, in which the sparks appear not only simple, but also very dull red. This, however, is easily understood by referring to the foregoing paragraphs where it is shown that the luminosity of iron or steel sparks depends for the most part on the combustion of the iron and carbon. Perhaps one of the most remarkable sparks which enter into this groop is characteristic of manganese, and widely differs from the familiar carbon stars and rays. Once these divirsified signs have been carefully studied, the trained eye will detect the slightest trace of manganese in even what is otherwise pure carbon steel. Its spark is shown in 5. The lateral darts always radiate from an unbroken line and at right angles thereto. The color is dull red and each dart is subdivided into a number of white hot globules.

"Some steelmakers in testing their products use the method of spark analysis in addition to others, and they agree that it is very reliable. There are also many mechanics who by experience have learned thus to distinguish tool steel from iron or machinery steel, and who are never caught making reamers and cutters of machinery steel or bolts and screws of tool steel.

"Perhaps the most misleading spark to be found is the one of gray or cast iron, which being very seldom of a standard purity will often show scarcely any luminous sparks at all. Sometimes it is rich in manganese, and the familiar bright manganese darts are given off at varying distances from the source of heat. Cast iron usually consists of iron with a very high percentage of carbon. Graphite in iron is that form of carbon which is not chemically united, and, therefore, it follows that since it exists in a free state, it must be present in all stages of combination. Thus cast iron will yield sparks ranging from iron to tool steel. In addition to the diversified sparks shown in the diagram there is also much significance in the distance at which they appear from the source of heat, as in grinding, which is the most accurate test."

DIFFERENT EXPERIENCES OF DIVERS AND CAISSON WORKERS

In the British Societies and in the technical press discussion continues as to the effect of compressed air upon the workers in it, the most noticeable feature being the differences in the experiences of submarine divers and the workers in caissons. Staff-Surgeon Oswald Reeves, R. N., Secretary to the Admirality Committee on Deep Diving, has prepared a memorandum on Caisson Disease which has been summarized by the *Engineer,* whose work we still further condense, more or less.

As a diver descends in the water, air is pumped to him and the pressure equals or only slightly exceeds that of the water at the head of the exhaust valve of the helmet. The caisson worker is seldom subjected to a greater pressure than 40 lbs., while a diver at 35 fathoms is exposed to a pressure of 93.6 lbs.

When a gas is in contact with a liquid on which it has no chemical action it is absorbed by the liquid in amounts which are proportional to the pressure under which the gas is at the time, and in the case of a mixture of gases each gas is absorbed as if it alone were present. In the lungs the air is practically in contact with the blood and each of the gases in the atmospheric mixture; oxygen, nitrogen and carbon dioxide, is absorbed in its due proportion. The oxygen is used up by the tissues, and the $C\ O^2$ is kept at a fixed percentage, no matter what amount is present in the air breathed. Nitrogen is absorbed unaltered and in an amount directly proportioned to the pressure.

So long as the diver remains under pressure there is no manifestation of the pressure of the absorbed gas, but as soon as the pressure is released as the diver ascends the gas should begin to bubble off. Fortunately, the blood is a sticky albuminous fluid in which bubbles do not form easily, and is capable of being supersaturated with nitrogen to twice its normal amount without the formation of bubbles. Fat can take up six times the amount of nitrogen that the blood can absorb. The comparative freedom of the diver from attacks of "the bends" is probably because his blood never becomes saturated as he is exposed to pressure for shorter periods than the caisson worker. The severity of the symptons in caisson disease bears a distinct ratio to the time of onset after the return of the diver to the surface; the quicker the onset the more severe the symptons, and *vice versa.*

A man who carries about with him a huge reservoir for nitrogen, as is provided by the abdominal fat, must, other things being equal, be more liable to the formation of bubbles than the thin, spare man. In fatal cases after sudden decompression bubbles have been found in the abdominal fat when there were none in the other tissues.

In cases collected the percentage ratio of illness to age was as follows:

Age.	Per cent of Illness.
15-20	....
20-25	10.3
25-30	14.3
30-35	20.9
35-40	22.9
40-45	26.3
45-50	66.0

The following indicates the influence of bodily habit on health:

	Spare.	Medium.	Heavy.
Men generally well.	25	14	3
Men taken sick....	26	22	36
Men paralyzed	2	3	8
Men died	..	..	3

Safety in decompression may be secured by two methods. 1. Limiting the time of exposure; 2, bringing the diver up slowly. In caisson work it has been found that by limiting the time of exposure to the compressed air cases of paralysis have been practically eliminated.

Various rates of decompression have been suggested, usually from twelve minutes to twenty minutes per atmosphere. The blood as it leaves the left side of the heart is always saturated with air to the existing pressure, and, in the same way will be desaturated to the same pressure. The blood leaves the arteries in less than half a minute, and in this time bubbles scarcely seem to form, so that there will be little risk of their actual formation in the arterial blood unless the ebulition is practically instantaneous. With very rapid decompression, however, small bubbles which have passed through the capillaries of the lungs may easily increase in size in the arteries.

This, however, is not the whole of the problem. All the blood passes through the lungs once a minute, and as it is at once desaturated to the existing pressure danger would cease one minute after sudden decompression, but, unfortunately, the saturation of the tissues must be considered.

Cases of accident are almost non-existent when the air pressure is less than 20 lbs., gage, and this immunity would seem to be due to the fact that bubbles will not readily form as long as the relative diminution of pressure is kept at a rate of 1 to 2.

In coming up from 33 feet to the surface, or from 99 to 33 feet, 165 to 66 feet, or 231 to 99 feet there should be no formation of bubbles, and, generally decompression can be safely proceeded with if the difference between the relative pressures of the air and nitrogen dissolved in the blood and tissues is not more than in the proportion of about 2 to 1.

This assumption is of great practical importance, as desaturation will naturally go on faster the greater the relative difference we can establish without undue risk. In gradual and equal decompression the absolute difference between the air pressure and the nitrogen pressure in the tissues necessarily goes on increasing, and is greatest at the end of the process. It is the *relative* and not the absolute difference in the nitrogen pressure that matters, so that the unsuitability of uniform decompression is evident.

The great advantage of the "stage" method has been proved by experiment. It was found that the time required to desaturate a diver who was completely saturated with nitrogen at 41 lbs., 95 feet, was at least 90 minutes. In 30 fathoms, 80 lbs., 3¼ hours would be required. Such a length of time is impossible for the diver, so it was found necessary to limit the extent of saturation, and tables have been prepared giving a scale of times that divers may be allowed to stay in deep water.

Bubbles once formed in any tissue of the body are liable to increase in size as long as the pressure of nitrogen in that tissue is greater than that of the air, and symptons may therefore go on increasing in intensity for two or three hours after decompression.

Researches of several investigators in this line, often carried out with much personal risk, have revolutionized the practice of compressed air working. It is now possible to carry out operations under air pressures and at depths formerly out of the question, provided due precautions and suitable methods of working are adopted. Lieut. Damont, the recently appointed inspector of diving in Great Britain, has descended to a depth of 210 feet witohut detriment to health, this being the record for diving work.

A BIG MEXICAN DRAINAGE TUNNEL

A tunnel of length and magnitude comparable with those of the Alps was begun some fifteen years ago near Pachuca, Mexico, for the drainage of the mines of Atotonilco el Chico and those adjoining. The work has progressed slowly, but there is prospect that now it will be pushed so rapidly that it will be finished in four years.

The tunnel is about 650 feet lower than the lowest mine in the vicinity. The total length of the tunnel will be over 6 miles, of which up to this time only about one mile has been driven at a cost of $142,000. A new water power plant is being installed near the tunnel, and electric air drills will be employed, when it is expected that progress will be made at the rate of 50 or 60 feet per week.

This tunnel commences at an altitude of 6,500 feet, and about a mile and a half to the north of Atotonilco el Chico, right at the junction of the rivers Milagro and Puente. The actual direction of the tunnel is 20 degs. 40 min. S. E. in order to pass near the California shaft which will be used for ventilation. Its direction then changes so that it will pass a little to the east of San Pedro shaft, then toward San Rafael and other mines north of Pachuca. The section of the tunnel is nearly 12 feet vertical and horizontal. To give the water an easy flow, and also that the cars may run by their own gravity the incline is 5-1000.

Although the tunnel is ostensibly a charitable enterprise, its earnings when completed being intended to be used for the erection and maintenance of a home for invalids and orphans in Pachuca, important practical results are expected from it, among which are the following: The possibility of making, at a depth never before reached by more than 300 meters, a very economical exploitation of all of the mineral veins of El Chico located in the mines of that company and that of Arevalo. This exploration could be made by means of a cut commenced from the Nepton, as the tunnel is named, and continued horizontally east and west inside of the respective claims without expense of constructing buildings, and with great economy in the way of management, drainage and extraction of ore.

The shaft of the California once crossed, the Nepton will change its course slightly to the west in order to connect with some of the cuts to the north of Pachuca. This long course will also make it possible to determine the structure and formation of the mountains that separate the mineral regions now known as Pachuca and Atotonilco el Chico, it being supposed that silver veins exist there.

Arriving, at two-thirds of its length, under the small surface of the Sabanilla the tunnel will cross the base of the boulders of crests of las Ventanas at a depth of 900 meters (the greatest) which should produce an increase in the temperature.

When the tunnel is in communication with the mines in the vicinity of Pachuca it will give them permanent and secure drainage and a cheaper extraction, making the same one-eighth of what it is at present. With these facilities it is expected that many new mines will be opened which will augment the riches of the republic.

The veins near Pachuca being reached it will be easy to follow any of them toward Real del Mone, and either in or out of a vein to Santa Gertrudis. The road being finished to San Juan and equipped with its indispensable railroad it would serve for traffic and could be used from Amajac towards the districts of Atotonilco, Metztitlan, Zacualtipan, etc., saving time, trouble and expense and avoiding the fatigue and time consumed by way of Britos or Casas Quemadas.

THE COST OF LAYING 6 AND 8-INCH WROUGHT-IRON SCREW-JOINT PIPE FOR AIR

By E. E. Harper.*

During the summer of 1907 the writer had occasion to lay about 7,000 ft. of 8-in. and 4,000 ft. of 6-in. well casing, to be used as an air line for compressed air at 80 to 90 lbs. pressure. Very careful attention was given to the cost of this work. In view of the scarcity of similar cost data, if any be available, I submit my itemized figures to the profession through your columns.

The work was all performed by common labor, none of the men being experienced in pipe-laying. The accompanying tables give the cost per 100 ft. of laying the 6-in. and 8-in. casing. The illustrations show the de-

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*Of Ward & Harper, Civil and Mining Engineers, Sturgis, Ky.

COST OF LAYING 6 AND 8-IN. (OUTSIDE DIAMETER) WROUGHT-IRON AIR-SUPPLY PIPE FOR THE FEDERAL LEAD CO., FLAT RIVER, MO.

6-IN., FROM NO. 9 SHAFT TO NO. 10 SHAFT.

Item.	Cost per 100 ft.	Remarks.
1 Size and kind	....	6-in. O.D. lap-welded casing. Weight, 15 lbs. per ft. Av. length of joints, 20.1 ft. Laid with sleeve couplings, 11½ hreads per in. Flange union every 150 ft. U-bends for expansion every 500 ft.
2 Length	....	4118 ft.
3 Surveying and superintendence	$0.70	
4 Cost of laying	3,137	Actual cost of connecting pipe. Cost per joint, 62.5c.
5 Av. ft. laid per day	....	*588.2 = 29.3 joints.
6 Crew and wages	....	Av. Crew, 4.85 men at 20c.; 1 foreman at 30c.; 1 waterboy at 10c. See premium schedule.
7 Clearing right-of-way	0.327	Small brush, etc. Cut line 10 ft. wide.
8 Hauling and distr.	1.578	Av. haul, 3,000 ft. bad roads, steep and rough. Includes loading pipe on cars and unloading and hauling and distr. Teams' and drivers $3 per day. Incl. 7 U-bends.
9 Blocking to grade	0.116	Includes temporary blocking and bending pipe in 5 places by building fires on same.
10 Cost of bents	0.45	Carpenter work only. About 20 bents. Av. 3 ft. height. 4 x 6-in. stuff.
11 Anchors for U-bends	2.29	8 piers, ¾ cu. yd. each, $12 each, incl. bolts and clamps. (Est. cost.)
12 Painting	0.90	Paint, $1 per gal. Labor, 20c. per hr. Pipe cleaned with wire brushes. Given 1 coat mineral paint. (Est. cost.)
13 Tools	0.10	Shopwork, depreciation.
14 Testing	0.30	(Est. cost.)
15 Total cost of laying	9.898	
16 Cost of pipe	....	
17 Weather, etc	....	Weather fair except 1 day. Men worked in rain 4 hrs. and laid 22 joints. Men walked 2½ to 3 miles to and from work. Time, Aug. 15 to 24, '07.

*Best day's work, 1065 ft. or 53 joints by 6 men, incl. foreman, or 177.5 ft. each, actual time 9 hrs. (See 17); 2d best day's work 883 ft. or 44 joints by 6 men, incl. foreman, or 147.1 ft. each, actual time 9 hrs. (See 17); poorest day's work 120 ft. or 6 joints by 6 men, incl. foreman, or 20 ft. each, actual time 9½ hrs. (See 17). No excuse except poor judgment and bad management of foreman.

8-IN.. FROM NO. 3 MILL TO NO. 9 SHAFT.

Item.	Cost per 100 ft.	Remarks.
1 Size & kind of pipe	....	8-in. O. D. Lap-welded casing. Weight, 20 lbs. per ft. Av. length of joints, 19.15 ft. Laid with sleeve couplings, 11½ threads per in. Flange union every 150 ft. U-bends for expansion every 600 ft.
2 Length of line	....	7,101 ft.
3 Surveying and superintendence	$1.00	
4 Cost of laying	3.58	Actual cost of connecting pipe. Cost per joint, 69.3c.
5 Av. ft. laid per day	....	*503.6 per day of 10 hrs. = 26.3 joints.
6 Crew and wages	....	Av. crew, 5.92 men at 20c. per hr.; 1 foreman at 30c.; 1 waterboy at 10c. per hr. See premium schedule.
7 Clearing right of way	0.187	Small brush, etc. Cut line 10 ft. wide.
8 Hauling and distr. pipe	1.0321	Incl. 12 U-bends, which cost $1 each to haul. Team and drivers at 30c. per hr.; laborers, at 20c.; foreman at 30c. per hr.
9 Blocking to grade	1.11	Temporary Supports. Bents put in afterward.
10 Cost of bents	1.0687	Carpenter work only. Abt. 80 bents of 4 x 6-in. stuff from 1 to 16 ft. high; av. 6 ft. high; spaced 30 ft. apart.
11 Anchors for U-bends	2.535	12 piers at 1 cu. yd. each, $15 each, incl. bolts and clamps.
12 Painting	1.20	Paint, $1 per gal. Labor, 20c. per hr. Pipe cleaned with wire brushes. Given 1 coat mineral paint.
13 Tools	0.1022	Shop work, depreciation, etc.
14 Testing	0.388	Includes laying & connecting 200 ft. of 4-in. pipe to pump line. Tested to 110 lbs. hydraulic pressure. Leaks developed at two tees in line, and these were repaired. Line tested again and found O. K.
15 Total cost of laying	12.203	Not including cost of pipe.
16 Cost of pipe	76.40	F.O.B. McKeesport, Pa., 76c.; frt. McKeesport to Flat River, 40c.
17 Weather, etc	....	July 2, '07, to Aug. 5, '07, weather hot and sultry most of time. Thermometer from 85° to 100° in shade; ave., 90°.

*Best day's work, 613 ft. or 32 joints by 6 men, incl. foreman, or 102 ft. each; 2d best day's work, 675 ft. or 35 joints by 7 men, incl. foreman, or 96.4 ft. each; poorest day's work, 380 ft. or 20 joints by 7 men, incl. foreman, or 54 each.

vices used to facilitiate the work. The greatest cause of delays in laying screwed pipe is the difficulty in getting each successive length of pipe into line and keeping it there until the first threads take hold and the pipe begins to screw together. To overcome this difficulty a cradle for supporting the pipe at the joint, a jack for adjusting and supporting the outer end of the pipe and a straight-edge for lining the pipe were de-

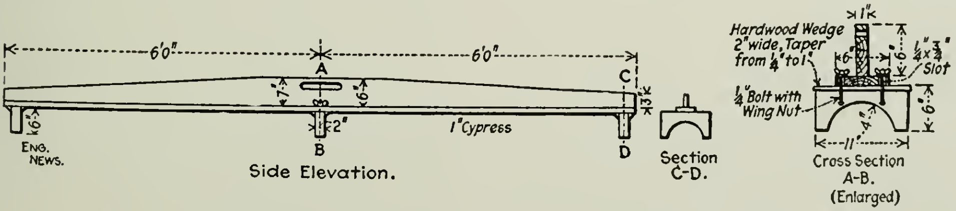


FIG 1.—STRAIGHT-EDGE USED IN CONNECTING SBREW-JOINT WROUGHT-IRON PIPE. (Adjusted as tested on a straight length of pipe.)

vised. The cradle holds the threaded end of the pipe in position to enter the sleeve coupling on the last joint laid; the jack allows both vertical and horizontal adjustment of the joint of pipe; and the straight-edge shows when the pipe is in line ready to screw together. The cradle was simply a wood block, 8 x 8 ins. x 24 ins. in length, with a groove having a 4-in. radius cut in its top. The jack is shown by Fig. 2, and the straight-edge by Fig. 1. The movable block on the straight-edge (Fig. 1) is necessary because it is almost impossible to make a 12-ft. straight-edge that will remain true for more than a day.

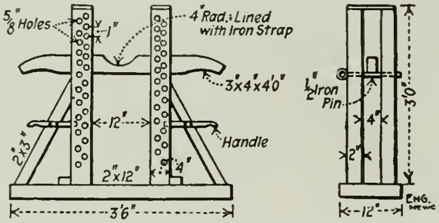


FIG. 2—JACK AND CRADLE.

***PREMIUM SCHEDULE FOR LAYING 8-IN. PIPE.**

After working four days the following schedule was adopted and the men were paid according to the number of joints laid per day. No deduction was made for U-bends or fittings.

A U-bend counted as 1 joint.

For every man added to the crew, add 3 joints.

For every man less than the crew, deduct 3 joints.

In counting joints, any odd joints carried forward and counted next day. Thus, 28 joints gives 11 hrs. time with 2 joints to credit of crew for next day's work.

Schedule for 5 men, 1 foreman, 1 waterboy.

22 joints (or less)	10 hrs. time for crew
26 joints	11 hrs. time for crew
29 joints	12 hrs. time for crew
32 joints	13 hrs. time for crew
35 joints	14 hrs. time for crew
38 joints	15 hrs. time for crew
41 joints	16 hrs. time for crew
44 joints	17 hrs. time for crew
47 joints	18 hrs. time for crew
50 joints	19 hrs. time for crew
53 joints	20 hrs. time for crew

*Same schedule used in laying 6-in. pipe, except that size of crew was reduced by one man.

These devices saved fully 50 per cent. over the crude and unsatisfactory method of using blocks to hold the pipe in line. There was no straining and lifting to hold the pipe in place, and as the pipes were started together straight there were no stripped threads and bad joints, and the pipe made up so easily that one man with a pair of 3-ft. tongs often screwed an 8-in. pipe half way up; it was then completed by four men using two pairs of tongs with 8-ft. handles.

The threads, both male and female, were cleaned with wire brushes. Dixon's pipe joint compound was used on all screwed joints. Ring gaskets of 1-16-in. rainbow packing were used on flange joints (see table), the gasket being pasted to one flange with coal-tar roofing paint, which held it in position while the joint was being made.

The premium schedule (see foot note to table) allowing overtime if more than a certain amount of pipe was laid per day, proved quite satisfactory and kept the men hustling. —*Engineering News.*

DRYING AIR FOR BLAST FURNACES

British patent No. 25112 of 1906 describes an interesting method of drying the air used in blast furnaces. A salt is used which takes up water of crystallization without deliquescing and which subsequently gives up its water at a comparatively low temperature. The sulphates of zinc, copper or magnesium are the most suitable. In preparing the drying apparatus, porous material, such as common brick, is immersed in saturated solutions of the sulphate and so impregnated with the hydrated salt. The bricks are then built up into the drying chamber, and subjected to heating by means of hot air or some inert gas. The water of crystalization is thus driven off and the bricks are then ready for dealing with the blast as it comes from the blowing engine. In practice, the drying chambers will be arranged in pairs so that one is drying the blast while the other is having its water of crystallization removed by the hot air, and the pair of chambers will be fitted with suitable reversing valves.

PNEUMATIC HAMMER POWER TESTS

The Engineer, London, did an excellent and eminently practical thing in arranging for a test of pneumatic hammers in regular blacksmith work for the purpose of determining the power consumed in operating them. The tests were made at the works of Messrs. B. and S. Massey, Openshaw, England. There were three hammers with falling weights of 1, 3 and 7 hundred weights respectively.

Fig. 1 shows the largest hammer from which the common type may be understood. It will be seen that they were not steam hammers of the regular type with compressed air substituted for steam as the actuating fluid, but were actuated by alternate pulsations of air from the inclined air cylinder at the side, the piston of this cylinder being driven from a horizontal crank-shaft belted to a line-shaft overhead. Only the actual air pressure required is produced; the air works with full advantage of its expansion, it being in fact merely a spring between the pulsator piston and the hammer piston. As the air does its work simultaneously with its compression, the usual heat losses are avoided. The line shaft, 3-inch diameter and 30 feet long with five hangers was driven by an electric motor, and an ammeter gave the means for an accurate record of the power consumption. The smallest hammer had a stroke of 12 inches and made 250 blows a minute; the second, 17 inches and 160 blows; and the third, 24 inches and 120 blows a minute.

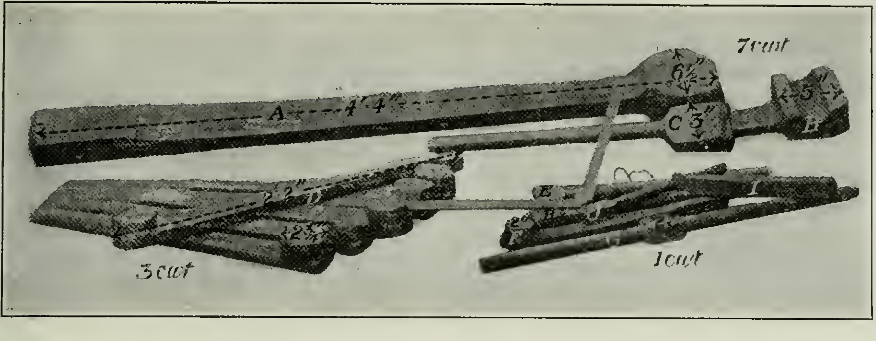


FIG. II.—SAMPLES OF WORK OF PNEUMATIC HAMMER.

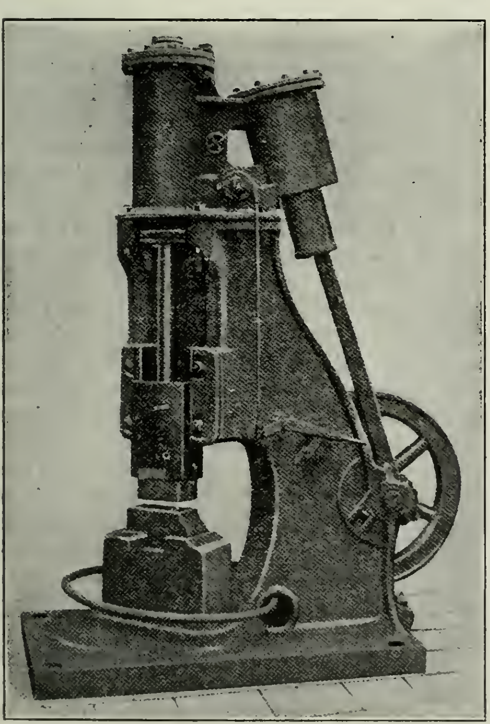


FIG. I.—PNEUMATIC POWER HAMMER.

Reference.	Job.	Size of hammer	Power, B. of T.U. (kilowatt hours) 1 cwt.	3 cwt.	7 cwt.	Total.
F	Lever		0·24			
C	Joint	(1st heat)			0·57	
D	Lever			0·66		
B	Swage	(1st heat)			0·44	
I	Tool		0·22			
D	Lever			0·34		
B	Swage	(2nd heat)			0·45	
G	Spindle	(1st heat)	0·13			
D	Lever			0·34		
B	Swage	(3rd heat)			0·45	
G	Spindle	(2nd heat)	0·24			
D	Lever			0 45		
A	Connecting-rod	(1st heat)			1·44	
E	Connecting-rod	(1st heat)	0·46			
D	Lever			0·56		
J	Joint		·41			
A	Connecting-rod	(2nd heat)			0·18	
H	Joint		0·24			
D	Lever			0·45		
Total power used in two hours by hammers (exclusive of transmission losses)			1·94	2·80	3·53	8·27
Ditto, per hour			0·97	1·4	1·76	4·13
Average power used by hammers (exclusive of transmission losses), B.H.P.			1·30	1·87	2·36	5·53
Power used in driving shaft and belts (average efficiency of motor 85 per cent.), B.H.P.						6·06
Average power for three hammers, shaft and belts, B.H.P.						11·59
Cost with engine power at ½d. per B.H.P. per hour, pence .. .. (or electric current at ·77d. per B. of T.U., average efficiency of motor being 85 per cent.)						5·8

TABLE OF PNEUMATIC POWER HAMMER TESTS.

A number of pieces of work were chosen to be done by each hammer. These are shown in three groups in Fig. 2, and the power results of the tests are given in the table. The average power used by the hammers, exclusive of losses in transmission, was 1.30, 1.87, and 2.36

brake horse power, while the average power required to drive the three hammers, with shafting, belting and bearing friction was only 11.59 brake horse power. The highest power required, with not more than one hammer operating at once, is 24 brake horse power. The total cost of power for operating this set of hammers through shafting and belts will, of course, vary with that of the motive power, but if a gas engine be employed giving 1 brake horse power for 1 cent, a fairly liberal figure, the cost would only amount to about 12 cents per hour.

THE EAST RIVER GAS TUNNEL

The first completed tunnel under the East River, that of the East River Gas Company, for the transmission of illuminating gas from the gas works in Long Island for distribution throughout Manhattan, was of unusual interest and importance in that its successful completion demonstrated the entire possibility of constructing similar tunnels under the same waterway wherever they may be required and also that the progress of the work revealed the peculiar conditions and the special difficulties which might be expected to be encountered in similar undertakings in the same neighborhood. This tunnel was not as large in section as would be required for a standard railroad, or even for trolley cars and general traffic, but it was still large enough to reveal all the difficulties which a larger construction would have involved. The rock section was required to be 8 1-2 feet high and 10 feet wide, and the heading was driven the full width. The location of the tunnel is from Webster Avenue, Ravenswood, Long Island under both channels of the East River, with Blackwell's Island between them, to Seventy-second Street, Manhattan. The roof grade of the tunnel was 40 feet below the lowest point in the bed of the river, which was in the west channel, and 111 feet below mean high water mark. The water in the east channel was not more than half so deep as that in the west channel so that the depth of ground over the tunnel was there much greater.

Preliminary investigation revealed bed rock on both sides of the river only a few feet below the surface and also on the island, and drill soundings made with difficulty in both channels seemed to show from two to five feet of sand and gravel at the bottom and then solid rock, so that the driving of the tunnel was expected to be a clean and uninterrupted job straight through, and the contract for the job was placed on that basis.

Work was begun by the contractors, McLaughlin, Reilly & Co., at the Long Island end June 28, 1892. Bed rock was found 9 1-2 feet below the surface, a compact gueiss almost approaching granite. Work commenced on the New York end July 10. The rock here was the regular micacious gueiss known as "New York rock." The rock in the New York shaft was straight grained with dip of about 10 degrees from the vertical, striking nearly north and south and becoming harder as the depth increased. No water or any abnormal difficulties were encountered and the bottom of the shaft was reached at the end of October, 139 1-2 feet below the surface. At the Long Island shaft the progress was not as rapid. The rock was seamy and much water was encountered. There was no reliable water supply for the boilers, and the water obtainable, although not salt, was entirely unfit for use and there were numerous stoppages during the entire continuance of the work on account of the water supply.

The care and precision with which the line was laid are indicated by the fact that when the headings met, 1,678 feet from the New York shore, the lines were within 1-2 inch of each other laterally and 1 1-4 inch vertically.

Two Ingersoll-Sergeant compressors were installed at each end of the tunnel, and drills of the same company were employed throughout the work. On the New York end the driving of the heading proceeded to a distance of 348 feet when a seam of decomposed rock was struck, a straight face across the heading. After advancing into this 9 feet it was found unsafe to proceed, the ground finally having reached "about the consistency of soup." A steel air lock 6 feet diameter and 10 feet long was made and fastened solidly in the rock, and working under air pressure was commenced, the initial pressure being 35 pounds; electric lighting was installed.

The heading was enlarged and changed to a circle 12 feet in diameter. The tunnel in this part was lined as it advanced with light plates of wrought iron connected with angle irons, and 12 inches of brick work was laid inside the plates. One half of the thickness of the brick was subsequently removed and a lining consisting of cast iron segments bolted together finished the job.

The working air pressure was ultimately raised to 48 pounds, which was higher than men had ever worked in before, and they began to experience serious difficulty in continuing the work. Four deaths in all resulted from the air pressure, and there were no other deaths or accidents in the entire progress of the work. The first man to die was a foreman. The second man had been long out of employment and was in very low condition. He died in the air lock after his first shift of two hours. The third man became paralyzed from his shoulders down and died soon after. The fourth man died nearly a year after the others.

In connection with this feature of the work the following rules for men working in compressed air were formulated by Dr. Andrew H. Smith of the Presbyterian Hospital:

Rules for Men Working in Compressed Air:

1. Never enter the air lock with an empty stomach.

2. Use as far as possible a meat diet, and take warm coffee freely.

3. Always put on extra clothing in coming out, and avoid exposure to cold.

4. Exercise as litle as may be during the first hour after coming out, and lie down if possible.

5. Use intoxicating liquors sparingly. Better not at all.

6. Take at least eight hours sleep every night.

7. See that the bowels are evacuated every day.

8. Never enter the lock if at all sick

9. In exit from the air lock, the time occupied should be five minutes for each atmosphere above the normal.

The earliest injurious effect experienced is an itching caused by air globules in the capillaries, which may be quickly cured by inducing profuse perspiration.

The "bends," a more serious trouble, is an intense rheumatic pain in the joints caused by air globules in the sockets.

Paralysis leaves lasting injury and is usually the cause of death when it occurs.

A highly steam heated dressing room was found beneficial, with copious supplies of hot, strong coffee

For pressures up to 30 pounds the men worked two shifts of four hours each, with one hour of rest between. For the highest pressure the men worked only 1 1-2 hours at a time, and 4 1-2 hours for the entire day.

The information herein contained is mostly abstracted from the report of the chief engineer, Mr. Charles M. Jacobs, Mem. Inst. C. E. Mem. Inst. M. E. The following narration of a bit of experience of Sunday, March 26, 1893, is quoted from the report. "In order to keep an exact record of the air pressure I had fitted up an Edson automatic recording pressure gauge with high and low pressure alarm bells attached. The foreman of the contractors with the engineer had broken the lock and removed the pencil. The fires were nearly out and the compressors were stopping, the pressure having fallen 11 pounds. A large quantity of soft ground had worked into the heading, entailing more exercise of ingenuity and determination to get things going right again. A great cavity had washed in and the water was bringing it down continuously."

In the progress of the work serious troubles occurred with the contractors who finally abandoned the entire contract. At one point they had to be restrained by injunction from removing their compressors at a critical time. The air pressure would not have been maintained and a general collapse might have resulted. The matter became a subject of litigation.

At the Long Island end of the work the troubles had their own individuality. Bad and insufficient water for the boilers caused frequent stoppages while it was essential to keep the pumps active to prevent drowning out. The first soft ground was met 253 feet from the shaft, and at 285 feet a green slimy and almost liquid material began oozing out, which so embarrassed the contractors that they then abandoned the work allowing the heading to fill with water.

The stringency of the money market in 1893 was another incident which caused a cessation of all operations for a couple of months.

A neighboring picnic place, "Jones's Woods," took fire and with it was destroyed the entire plant at the New York end, and before pumps and compressors could be installed the heading was drowned out again.

The time of greatest anxiety, difficulty and risk was when in advancing the shield at the New York end a shelving bank of rock was found in front of the bottom of the shield, while at the top was the softest black mud. It was necessary to blast out this rock in the floor in advance of the shield and to get through the bulkhead which had been put in when the work had been abandoned. Direct communication was opened with the river, so that refuse and even live crabs came into the tunnels. The leakage of air was so great that both compressers at the limit of their speed had difficulty in maintaining the pressure of 48 pounds. The difficulties continued until the shield was entirely entered into the black mud, when the pressure was reduced and the shield was advanced at the rate of 6 feet per day. The shield was pushed forward by twelve hydraulic jacks with a combined thrust of 600 tons. The second soft place extended 98 feet. The rock ahead was badly seamed, but finally became solid again and then in two weeks 101 feet and 94.6 feet advance respectively was made, which rate had never been surpassed in that class of rock.

The headings met July 11, 1894, 1,676 feet from the New York shaft. The total distance from shaft to shaft was 2,550 feet, so that two thirds of the length was driven from the New York end. When working in solid rock the average progress was 69 feet per week. Bonuses were given to foremen and to some of the gang leaders.

Considering the unexpected difficulties encountered and the delays from so many different causes the total time from the beginning to the completion of the tunnel, a few days over two years, must be considered remarkable, and could only have been possible with constant resourcefulness and untiring push. After the ends met there was little more to be done and in a very short time a 36 inch gas main was laid with an uninterrupted motor car track at the side of it.

The best preventive of the spontaneous ignition of coal is a small cylinder of compressed carbon dioxide fitted with a fuse plug melting at 200°F. A cylinder 1 ft. long and 3 in. diam. would be sufficient to fill the pores of 8 tons of coal.

ARTESIAN WELL PUMPING BY COMPRESSED AIR

By H. Tipper, M. E.

The economics of artesian well pumping is, particularly to the people of the Southwest, an important question. There is only a small amount of surface water in that district and of that none can be used safely without thorough purification. Artesian water can be obtained with ease, in a great majority of cases, and while it may contain permanent and temporary hardness, it is free from all dangerous contamination.

Engineers, independently of the large manufacturers of compressed air apparatus, know very little about lifting water by air, and the writer has observed case after case where this has been the cause of disastrous and costly experiments, both in private and city plants.

The proper proportion of air and water pipes, the proper submergence, the condition of the casing, and the style of lift used are points which appear to receive vastly too little attention from the people in charge, with the result that the practice of using compressed air gets saddled with faults not of its making.

The assumption that an air-lift system is getting the best efficiency of a well because the water is being delivered and there is no apparent defect is responsible for the absence of any general reliable data from independent sources on this subject, at least so far as it pertained to the Southwest, and it is to state the conditions in this territory, as found by the writer, that this article is written.

The sands from which the artesian water is secured in the State of Texas vary largely in their textures, their static head and the depth at which they are found. Thus, at El Paso there are four or five water-bearing strata within 300 ft. of the surface, and the static head from any of these comparatively small. North Texas is supplied from the Trinity sands and from the Paluxy sands. Of these sands the Trinity sands are the greatest and most important. Borings have been made and artesian water supplied from these sands in the larger part of Texas, including Fort Worth, Dallas, Waco, Austin and San Antonio. The Trinity sands are generally a white quartz, but vary greatly in texture, in different portions of the strata.

In addition to the cities named, a number of smaller towns, and a larger number of private plants, take their water from the Trinity strata.

In Forth Worth the depth of the sand from the surface is about 1,000 ft. and the static head about 900 ft.; in Dallas the depth is almost 2,000 ft., and wells have flowed there with 100-ft. head pressure.

In Waco the wells all flow, though not sufficiently to be able to supply the town without pumping. All along these sands the conditions are good for artesian pumping with compressed air. In the first place the lift is not more than 150 ft. The submergence can be placed at the most economical point, and the water which is secured is of excellent quality.

It has been necessary for the writer in the course of business to investigate the condition of numbers of wells, and in very few cases, so few as to be hardly worth considering, have the wells been in a condition which would make economic pumping possible. The chief difficulties found are:

(1) Bad casings. In a large majority of cases the wells have been shot with dynamite at the least suspicion of not delivering the required amount of water. Frequently this has been done carelessly and in such a manner as to irreparably damage the casing, and allow the air to escape into the surrounding strata instead of being engaged in lifting the water. In many instances the casing had been allowed to rust and become perforated with holes so that it was of no value for use with an air-lift. There seemed to be little or no attempt to keep the casing in good condition.

(2) Badly proportioned air and discharge pipes, and poor arrangements of pipes. The use of air pipes of altogether too small diameter is common. This causes a frictional resistance of a very expensive character. There may also be noted an absence of any attempt at proportioning the discharge pipe so as to get the most economical delivery of water from the well.

(3) The choking of well with the remains of rotted pipes and former attempts at pumping. It is surprising how often this occurs.

(4) The absence of any tests, or any means of ascertaining comparatively the performance of an air-lift at one date with another.

It is absolutely amazing how much in the dark the people using artesian water frequently are as to the amount received. Even in large cities like Fort Worth and Waco there are no records of tests made on the wells to ascertain the amount of water received or the cost of obtaining it.

The cost of obtaining water from the artesian strata by air-lift varies with the lift and submergence, but in the average a great deal of the cost is due to neglect. In my investigations of the subject I have found that the efficiency of the air-lift in moving water from the same strata practically through the same lift and under similar conditions runs all the way from 5 to 25 per cent.

The cost of delivering the water, depends in the first case on the compressor, and the great difference in compressors allows of some consideration of that subject.

The volumetric efficiency of the air cylinder of a 250-cu.-ft. compressor ought to reach 85 per cent., yet I have found that badly constructed valves and long narrow heated ports have reduced this to 40 per cent. in several cases.

The intake valves of the compressor should be a large part of the cylinder area, they should be placed and posted so that the rise in temperature of the air before it reaches the cylinder will be a minimum. They should, if possible, provide against any chance of irregular wear. The discharge valves should leave as little as possible of clearance, so as to keep the volumetric efficiency high and should be kept away from the intake valves.

It cannot be regarded as good construction for the intake and discharge valves to use the same ports: as the passage of the heated air, when discharged, over the metal over which the intake air must afterwards pass, results in the heating and expansion of the incoming air unnecessarily and consequent loss of efficiency.

The state in which compressors are allowed to run is one of the marvels which keep an engineer guessing. While the steam engines of the plants receive the best attention, too often the compressor must take care of itself, and it is to be regarded as to the credit of compressor manufacturers that they stand the strain so well. I have seen compressors running with the intake pipes open not 6 ft. from a boiler furnace, absorbing all the dust from the boiler front and running it into the cylinder to the detriment of valves, cylinder and all other parts around the cylinder. In the same place was being used, in the air cylinder, a thick black steam cylinder oil, and the thick oil and dust must have formed an excellent grinding material round the piston.

The next question relates to the piping of the well, and here a great deal of damage is done and a great deal of unnecessary expenditure incurred. I counted in four weeks, in this territory, over 25 cases where air lines of 1 in. had been used to supply air for 6-in. wells, with the inside air-line system. The average length of the pipe was 350 ft. from the well top; and often it was another 300 ft. to the compressor. Figure out the frictional loss occasioned by this, and the additional load thrown on compressor by the loss. These wells were pumping an average of 75 gals. per min. and using a compressor delivering 200 cu. ft. for the work, with a net efficiency of about 6½ per cent. After altering one of these pipes to a 2½-in. pipe above the well, putting in a receiver storage at the discharge of the compressor, and putting a 2-in. pipe down in the well, the average delivery reached 180 gals. per min. with the use of a little less than 200 cu. ft. of free air, the efficiency in this case being about 23 per cent.

In another case I found two wells of different depths, worked by different pressures, being fed from the same pipe, with of course the absolute loss of one well.

In experimenting with the matter I have found that a large receiver capacity, and a large pipe above ground, a 55 per cent. submergence and a frictional loss of not more than 5 per cent. allowed for in the piping proportions in the well bring the best results. With these and a lift of not more than 200 ft. I have been able to get an average of at least 1 gal. of water per cu. ft. of air per min.

The use of long lines of discharge pipe from the well horizontally, instead of allowing the well to discharge into a basin and the water to flow thence by gravity or be pumped by separate pumps to its required place, have a bad effect on the efficiency of the air-lift and should never be used. The most efficient scheme is a straight lift either to surface or elevated tanks, all long horizontal work to be taken care of by separate pumping system.

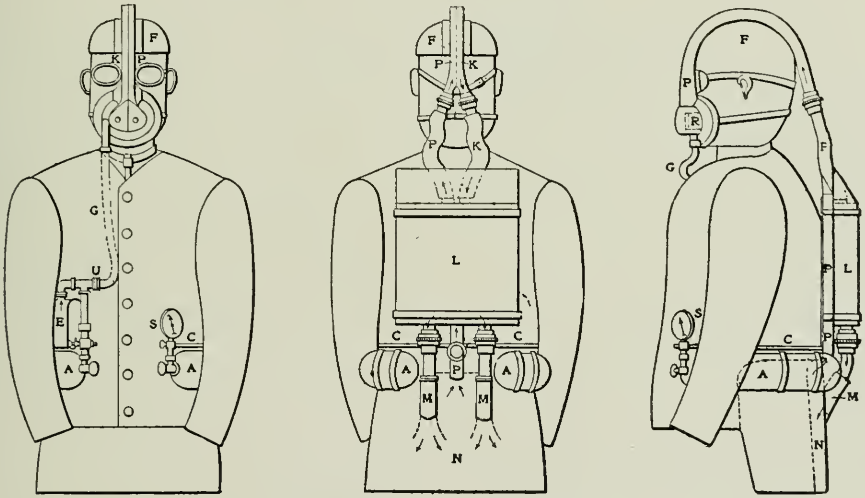
The ultimate economy of the air-lift as compared with pumping jacks, or with deep-well pumps, whether steam or electrically-driven, depends not at all on the efficiency, as, percentage for percentage, it is the most expensive system of pumping. Its utmost efficiency is not more than 25 per cent. to 30 per cent., while that of deep-well pumps, especially of the double-acting type, runs very much higher. The economy in the air-lift lies in its power of supplying a much greater quantity of water from the same sized well than the deep-well pumps, except in cases of low submergence, when it is useless to install the air-lift.

Not being limited to a certain displacement capacity, the quantity of water that can be raised by the air-lift is limited only to the amount possible for that sized pipe to carry at the velocity reached from the pressure of air employed. There is also economy in the absence of working parts down in the well and in saving frequent repairing to these with great loss of time and money. Properly installed and properly attended to, the air-lift system of delivering artesian water, while mechanically inefficient, represents the least troublesome, most desirable and most easily looked after system of obtaining the water under these circumstances at present in use.—*Engineering News.*

THE WEG BREATHING APPARATUS

The mechanical drawing, here reproduced from the *Engineering and Mining Journal* of a man equipped with a breathing apparatus for use in rescue work where the air has been rendered unbreathable by fire or explosion, has a decidedly steam boiler effect. There is, however, no boiler plate about it, the entire apparatus weighing only about 30 lbs., and being worn or carried without discomfort.

The wearer breathes into and out of a bag which is provided with such arrangements that the carbon dioxide is absorbed and oxygen is supplied from a steel cylinder to replace that which is used up, the supply of oxygen being regulated automatically with the consumption. The cap *F* fits the head of the wearer, and each cap has to be fitted to the individual head. It is not in the nature of a diver's helmet. The fact of its fitting this way provides, as it were, a safety valve in case the pressure inside should for any reason become too great. The oxygen cylinders are shown at *A*. The negative pressure of inhalation draws oxygen through the special regulator *E* and up the pipes *C* into the pipe *P*. The air expired by the wearer passes down the pipe *K* to the potash purifier *L* on the back, and after having its carbonic oxide removed, passes through the pipes *M* into the breathing bag *N* below. From this breathing bag the air is drawn up through the pipe *P*, where it is revived by the admission of oxygen as described. Valves are arranged at various points so that this circulation of the air is properly maintained. There is a pressure gage at *S*, and a direct pipe *G* which in case of emergency can be used to supply oxygen direct to the mouthpiece. The cylinders contain 150 liters (5 cu. ft.) of oxygen at the atmospheric pressure, and the consumption varies from ⅓ to 1⅔ liters (20 to 100 cu. in.) per minute.



THE WEG RESCUE APPARATUS.

The apparatus takes its name from the initials of its designer, Mr. W. E. Gorfarth, and is in use in the Altafts collieries, Yorkshire. Various tests have been made of it by the Royal Commission, in the experimental gallery filled with unbreathable smoke.

In the first test the subject worked very hard for two hours, lifting weights chiefly, the total work being 77,000 ft. lb. The analyses showed that the absorption of carbonic acid was good, and the constantly rising percentage of oxygen indicated that the apparatus was being washed out all the time. The consumption of oxygen was only 1¼ liters per minute.

The second test commenced with a period of rest extending over an hour and a half. The subject then used less than ⅓ of a liter of oxygen per minute. Afterward an hour and a quarter's hard work was done, during which the measured work was 92,000 ft. lb. The consumption of oxygen rose to 0.7 liter per minute. In the third test there were five men at work for 1¼ hours extinguishing fires, putting up screens, and carrying stretchers. The average consumption during this test was as high as 1.6 liters per man per minute.

A bill has been introduced in the British Parliament "to promote the earlier use of daylight in certain months of the year. The scheme is to advance the clock 20 minutes on each of the four Sundays of April. It is stated that the saving of daylight in the six summer months would amount to about 700 hours, and by going to work earlier the artisan would acquire command of long afternoons for recreation or study. The saving in artificial light is figured at $10,000,000 per year.

PINTSCH GAS AND CARBURETTED AIR SYSTEMS OF CAR LIGHTING

The following we take from a paper on "Car Lighting" by Mr. R. M. Dixon, President of The Safety Car Heating and Lighting Company, presented at the meeting, Jan. 14, of the American Society of Mechanical Engineers.

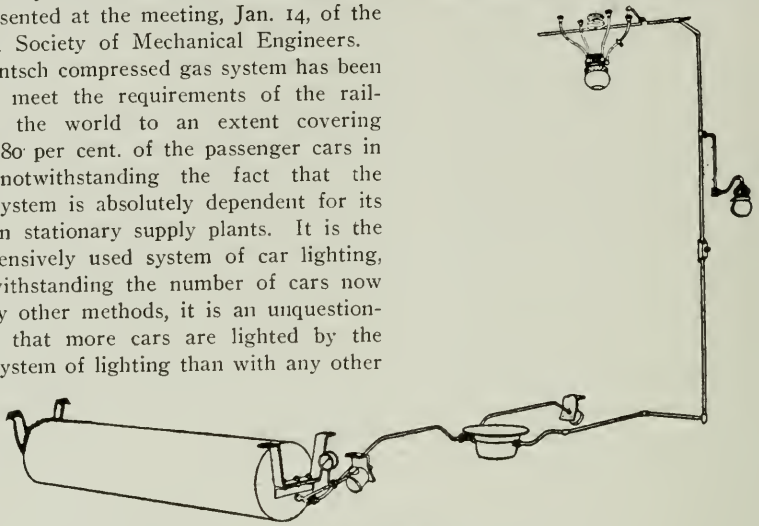


FIG. I.—PINTSCH GAS EQUIPMENT USING MANTLE LAMPS.

The Pintsch compressed gas system has been found to meet the requirements of the railroads of the world to an extent covering probably 80 per cent. of the passenger cars in service, notwithstanding the fact that the Pintsch system is absolutely dependent for its light upon stationary supply plants. It is the most extensively used system of car lighting, and notwithstanding the number of cars now lighted by other methods, it is an unquestionable fact that more cars are lighted by the Pintsch system of lighting than with any other light at any time. The gas is produced by the fractional distillation of petroleum oil and the apparatus is especially arranged to produce gas which will lose a minimum amount of its illuminating value in the compression to which it is afterward subjected, namely, about 200 pounds per square inch. It is stored at the plants under this pressure in vessels which are connected by pipe lines to the railroad yards to which it is charged by equalization from 150 to 180 pounds into the tanks suspended from the floor framing of the cars. At the present time there are seventy of these plants established; their distributing systems being connected with about 350 railroad terminals, thus enabling managements of railroads to apply gas lighting to cars without expense for gas supply plants.

The gas furnished is measured by the increased pressure in atmospheres times the volume of the tanks on cars in cubic feet the railroad company paying for the net amount of gas supplied to the tanks. Car tanks are of welded steel, 21 inches in diameter and either 8 feet 6 inches or 9 feet 6 inches long, the shorter holder contains 19 cubic feet per atmosphere and the longer one 21.18 cubic feet per atmosphere. In many instances more than one tank is applied to a car. The normal charging pressure is 10 atmospheres. There is a filling valve on each side of the car for convenience in filling, and a gage located near the tank underneath the car indicating the initial and final pressures. See. Fig. 1. The high pressure piping system consists of a ¼ inch extra heavy wrought iron pipe extending across the floor of the car to the filling valves with a branch to each tank and a short branch to the reducing valve or pressure regulator, located underneath the car near the tank. From the pressure regulator a ½ inch standard wrought iron pipe conveys the gas underneath the floor at some convenient point and then to the roof where a distributing pipe extends on the outside with branches to each lamp.

Until recently the gas has been burned in standard four flame lamps of various designs finished to harmonize with the interior construction and ornamentation of the cars. The aggregate consumption of the four flame lamp is about three cubic feet an hour and the illumination about thirty-three candles light. About three years ago, by the development of an inverted mantle which is sufficiently substantial for railway service, it became possible to get 90 candles light from the same consumption of gas, that is, three cubic feet per hour. This required the use of a cluster of four mantles but still more recently a mantle has been developed which, with a consumption of two and one-eighth cubic foot per hour, gives from 95 to 100 candles light, or per cubic feet of gas nearly fifty candles. At the standard selling price of the gas the cost of operation of these lamps is but one and one-sixteenth cents an hour.

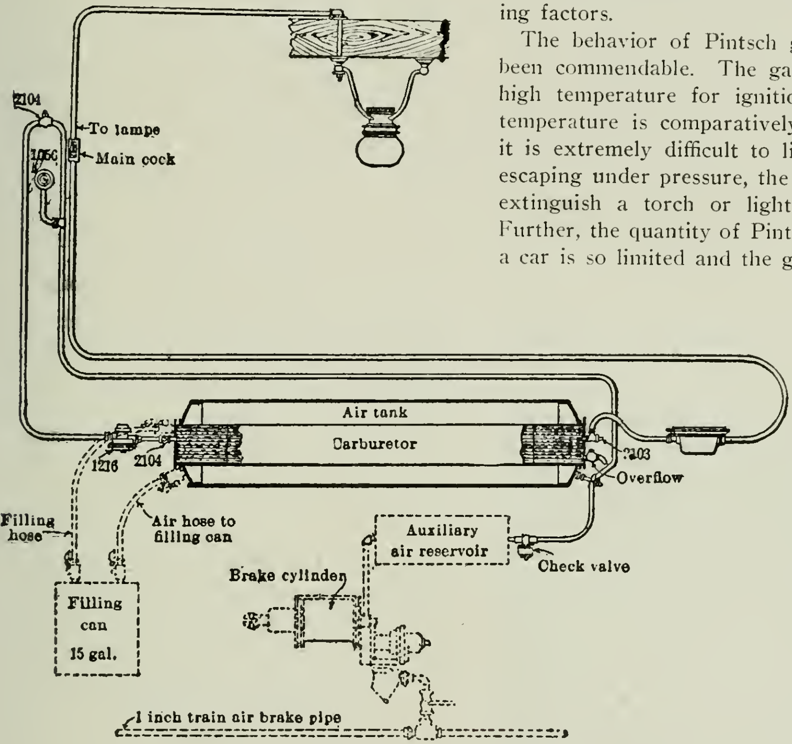


FIG. 11.—INCANDESCENT VAPOR CAR LIGHTING.

Mantle lamps are giving great satisfaction to the railroad managers. More than three thousand cars in America are now equipped with them and they are securing quite a general adoption in Europe. The Prussian State Railway Administration has contracted for about thirty-eight hundred new cars fitted with mantles, and for the change of their present equipment before the end of the year 1909. In France more than 10,000 cars are equipped and on order. Pintsch equipment has been applied to more than 160,000 cars, aggregating more than 1,000,000 center lamps and more than 400,000 tanks: 33,000 cars have been equipped in North America and the entire equipment is available for use with an expense of but $100 or $125 per car, thereby increasing the light three fold and reducing the consumption of gas 30 per cent., increasing the carrying capacity of the tanks and the capacity of the established gas plants about 40 per cent., thus more than trebling the value of the equipments owned by the railroad companies as light giving factors.

The behavior of Pintsch gas in wrecks has been commendable. The gas itself requires a high temperature for ignition, and the flame temperature is comparatively low. Moreover, it is extremely difficult to light the gas when escaping under pressure, the tendency being to extinguish a torch or light brought near it. Further, the quantity of Pintsch gas carried on a car is so limited and the gas is so free from vapor and its diffusion so rapid, that in the case of the rupture of a tank or the pipe connections, it is so quickly dissipated that an explosive mixture or a combustible condition is not readily obtainable.

For those cars which are in service and which do not reach Pintsch supply plants, a system has been developed for lighting by the use of carbureted air in connection with the incandescent mantle lamps. This system has been made possible by the mantle lamp development for railroad service. One disadvantage of the earlier systems was the low luminosity of air gas in cold weather. With incandescent mantles is is possible to obtain good results with gas that is non-luminous. Another disadvantage of the old system came from the fact that a carburetor had to be placed directly over each lamp as it was impossible to have one large carburetor supply all of the lamps, owing to the collection of condensation in the pipes from a fall in temperature.

If the gas be non-luminous in quality, no condensation in the piping can take place at ordinarily low temperatures. In this new system the gas is always of this quality. This uniformity of quality is accomplished by varying the pressure under which the gas is generated in the carburetor, in accordance with the temperature, making it possible to use a carburetor of substantial construction under the car, and distributing the gas to the lamps by a piping system similar to that for cars lighted by Pintsch gas.

The operation of the system is as follows: air is taken from the auxiliary air brake reservoir, see Fig. 2, through a check valve to the air storage tank, and from this tank up to the saloon of the car where a pressure gage and shut off valve are placed. This gage shows the pressure of air in the air storage tank. From the saloon the air passes to the high pressure regulator which delivers a pressure on the carburetor in accordance with the temperature. In passing through the carburetor the air takes up sufficient gasolene vapor to make the proper gas. From the carburetor the gas passes through a low pressure regulator which reduces the pressure to that suitable for burning in the lamps. The lamps are similar in design to those used for Pintsch gas, and use the same mantle. The carburetor is contained within the air storage tank and is formed by a 12 inch pipe through the center of a steel holder 21 inches in diameter. The ends of the pipe are brazed to the heads of the holder and closed by iron plates securely bolted on. The pipe is packed full of absorbent wicking to hold the gasolene. The air passing through this wicking takes up the proper amount of vapor to form the gas. By this construction the carburetor is well protected by the walls of the air tank.

A combined air tank and carburetor, 21 inches in diameter by 8 feet 6 inches long, has when charged, 20 gallons of gasolene and will supply five 100 candle power lamps for at least 200 hours.

AIR WASHING AND HUMIDIFYING FOR INDUSTRIAL PURPOSES*

For years it had been taken for granted that good ventilation must be obtained often at the expense of cleanliness. This is particularly noticeable in communities where soft coal is used. The necessity for properly cleansing the air which is taken into buildings has long been felt, and many have been the devices used to effect this. Prominent among them might be mentioned the use of cheese cloth screens, long bags of the same material, and coke filters. These all had the disadvantage of offering too great a resistance to the passage of the air, besides giving only crude cleansing effect. They were also unsatisfactory in that they did not affect the humidity of the air to any extent.

REGULATION OF HUMIDITY DESIRABLE.

The desirability of controlling the humidity of buildings has been well brought out in a paper by an eminent specialist, Dr. Henry Mitchell Smith, read by him before the Brooklyn Medical Society in May, 1903. In it he points out that the sensible temperature of the human body more nearly corresponds to the temperature indicated by the wet bulb of a hygrophant, rather than to the dry bulb temperature. Air at 68 degrees, and containing 50 per cent. humidity, feels more comfortable than air at 75 degrees, and having but 20 per cent. humidity. Extremely dry air produces a more rapid evaporation from the mucuous membranes as well as from the entire surface of one's body. This causes the lower sensible temperature and, in the case of the former, has an unhealthful effect.

It is just this condition which is obtained where external air at a low temperature is heated to the temperature usually found in warmed buildings. If we take outside winter air at 30 degrees F. and 80 per cent. saturation, we find it contains 1.5 grains of moisture to the cubic foot. If its temperature is raised to 70 degrees without adding any moisture to it, we find that its per cent. of saturation is but 19.5, because of the fact that air at 70 degrees can absorb 8 grains of moisture. We can thus see that not only is it desirable to humidify the air, but also to regulate the degree of humidity.

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*A paper (somewhat abridged) read before the Ohio Society of Mechanical, Electrical and Steam Engineers, by W. A. Rowe.

THE WATER SPRAY.

These considerations all lead to the use of a water spray by which to cleanse and humidify at the same time. There are various essential features which must be incorporated in the design of such an apparatus to make it successful, not only from a theoretical point of view, but also from the practical or commercial standpoint. In discussing these features the writer will describe one apparatus in particular which, by reason of its having met all the requirements successfully, has enabled its manufacturer to realize certain results of great commercial importance.

INTIMATE CONTACT BETWEEN AIR AND WATER.

The first requisite of a successful washer is an intimate contact between the air and the water. The more finely the water can be divided the greater will be the contact surface and, consequently, the greater the degree of success realized. Hence a finely divided mist is essential. An ingenious nozzle has been devised with which an almost invisible finely divided spray is obtained with a pressure of but 20 pounds per square inch. In this nozzle the outlet orifice is but 3-32 inch in diameter, yet it will deliver 3.5 pounds of water per minute. The result is obtained by giving the water a centrifugal motion which causes it to burst into spray. It is easily accessible for cleansing and is of the utmost simplicity.

In the complete air washer these nozzles are spaced two to the square foot of cross-section area, a velocity of from 400 to 450 feet per minute through the washer being maintained. Thus where 42,000 cubic feet of air per minute is to be handled a cross-section area of 93.5 square feet, with 188 nozzles, is provided.

SEPARATION FROM AIR OF EXCESS MOISTURE.

The second important feature to be secured is thorough separation of the excess free moisture which is carried along by the air current. This is done by a series of galvanized plates placed ⅞ inch apart and containing bends 2 inches in length. There are usually six sections, the first three allowing a film of running water to completely cover them. The last three have slight projections which completely separate all traces of free moisture from the air. This eliminator thus presents a large washing surface upon which every particle of foreign matter will impinge. The construction gives 11½ square feet of washing surface for every square foot of cross-section area of the washer. The lack of resistance of this arrangement has been proved by the results of tests which show that never more than 0.1 inch water gage is ever caused by the whole washer.

CONTROL OF HUMIDITY.

The proper control of the humidity is a third requisite equally important with those already named. This is accomplished by controlling the temperature of the air in the spray chamber, and taking advantage of the law that air at any given temperature has a definite moisture absorbing capacity, this amount increasing as the temperature is raised. For example, air at 50 degrees and 70 degrees F. can absorb 4 and 8 grains of moisture, respectively, per cubic foot, at which points it becomes saturated. If it is desired to maintain 50 per cent. humidity at 70 degrees in a building, it is only necessary that the air in the spray chamber be saturated at a temperature of 50 degrees, and then afterwards raised in temperature to that of the room, without the addition of any more moisture. In this way any desired humidity can be maintained. The best results are obtained by dispensing with tempering coils entirely, depending on heated spray water to bring the temperature of the air up

ATOMIZING JET.

to the desired point. This circulating water can be heated in any type of heater, its temperature being controlled automatically by means of a thermostat in the spray chamber.

REQUIREMENT OF DESIGN AND USUAL EQUIPMENT.

The last point and by no means the least, is that the apparatus must be free from all necessity for constant personal attention. It must be easily accessible, the nozzles easily cleaned, if such necessity should arise, and ample provision should be made for keeping foreign matter out of the circulating water.

Usually a motor driven centrifugal pump is used, the water collecting in a settling tank at the base of the washer and being recirculated. The water level in the tank is kept constant by means of a ball float and valve which replenishes that absorbed by the air in passing through. A large brass screen of 1-32 inch mesh is usually placed across the settling tank through which the water must flow before reaching the foot valve of the pump. A specially designed strainer is also placed in the discharge pump as an extra precaution. It is found that even in the dirtiest places the apparatus can run for one week end to the other, the only care being the oiling of the pump and motor bearings. Usually the settling tank is flushed out once a week and entirely new water provided. In the case of the air washer previously mentioned, having a capacity of 42,000 cubic feet of air per minute, a 2-inch centrifugal pump is used and operated by a 3-horsepower motor, circulating approximately 90 gallons of water per minute.

It is often desirable to place a distributing plate in front of the washer in order to thoroughly distribute the current of air throughout the washer. This can easily be done by means of a galvanized iron partition in which holes are punched to the extent of about 50 per cent. of the free area through the washer, the slight resistance of such a distributing plate never being over 0.05 inch water gage.

Some idea of the extent to which the cleansing effect may be carried may be obtained from recent tests made on the Carnegie Branch Library at St. Louis by Wm. H. Bryan, consulting engineer. While not going into unnecessary details it is sufficient to say that using lampblack, over 99 per cent. was removed by the washer.

CONDENSATION OF HUMIDIFIED AIR MAY BE PREVENTED.

We have already mentioned the desirability of humidity control and the means by which it is obtained. The use of hot circulating water instead of tempering coils has also been mentioned. By this means considerable saving of expense is effected and all possibility of freezing the coils is eliminated. Neither do we get sudden changes in temperature of the tempered air such as is possible where a by-pass damper or diaphragm valves are used controlled automatically by a thermostat.

Objection has been raised that excessive condensation on windows might result from humidifying the air. It has been found that this can be obviated by maintaining a temperature in the spray chamber never higher than a mean between the temperature of the external air and that of the room. For example, if we are maintaining a temperature of 70 degrees in the building, with an outside temperature of 10 degrees, a temperature of 40 degrees in the spray chamber will prevent any condensation or frosting on the windows. This is true because the glass itself is at a temperature midway between the two extremes and, therefore, is unable to lower the temperature of the air to its dew point.

HUMIDITY LOWERS TEMPERATURE OF AIR.

As a rule the fan system of heating and ventilating is only used when the outside temperature is under 60 or 65 degrees. Under these conditions an excessive humidity is absolutely impossible because of the fact that the air is raised in temperature before being brought into the room. When, however, the system is used throughout the year it often becomes desirable to get away from the high humidities quite common in warm weather. It is found that the external air can be appreciably lowered in temperature during the warm months, because the air in passing through the washer absorbs some of the moisture. The latent heat to vaporize this moisture is furnished by the air itself, hence the lowering in temperature. It is found that an absorption of from 0.8 to 0.9 grain per cubic foot gives a lowering in temperature of from 7 to 8 degrees. Greater reduction in temperature may be obtained, providing, of course, the air has not already too high a percentage of humidity.

In the greater part of our warm weather this cooling effect is not accompanied by any unpleasant humidity. Where, however, this slight increase would cause inconvenience it is possible to produce a cleansing effect without appreciable absorption of moisture, with its consequent cooling effect, by merely flooding the eliminator plates and dispensing with the fine spray. Where exceptionally high humidities are encountered, it is possible to substitute a solution of calcium chloride, 28 degrees Baumé. This solution will thoroughly wash the air without a particle being evaporated. It neither gives up nor will it absorb moisture.

In a recent test of the Carnegie Library installation, about which we have previously spoken, with an outside temperature of 86 degrees and 40 per cent. humidity, an average temperature was maintained inside the building of 77.5 degrees with 70 per cent. humidity, this being an average temperature decrease of 8.5 degrees. It was found that a lower temperature was maintained in the rooms where the windows were kept shut.

EXTRACTING MOISTURE FROM AIR.

So far we have touched only on the humidifying or adding of moisture to the air. In some branches of industrial work it is necessary to extract the moisture from air or to dehumidify it. This is particularly true in the case of drying many substances which cannot stand a high temperature. Among these might be mentioned gelatine and glue products, photographic paper, rubber, sulphur, matches, etc.

Where the material to be dried can stand the maximum probable temperature that we are likely to encounter in summer weather, say 90 degrees, we can get sufficiently dry air at any time by the use of calcium chloride solution, 40 degrees Baumé, in the air washer. This solution will extract moisture from the air, the amount depending on the strength of the solution. It is not necessary to use outside air in this instance. The air from the drying room can be returned to the washer, where it is relieved of a portion of its moisture. This chemical extraction of the moisture from the air liberates the heat of vaporization, which results in raising the temperature of the air itself. This warmer and dryer air is then returned to the drying room where it absorbs additional moisture from the material being dried. Of course the calcium chloride solution is being continually weakened while this cycle is progressing. It is necessary to use an automatically controlled evaporator to which the solution is returned where it is reconcentrated.

A more simple solution of this problem can be secured where a sufficient supply of cold water is available. With a temperature of water of 50 to 55 degrees, it is possible to reduce the temperature of the air to 58 to 63 degrees, leaving but 5.5 to 6.5 grains of moisture per cubic foot in the air. By then reheating this air to 80 to 85 degrees, we would have a 50 per cent. saturation, in which condition the air will readily absorb moisture. The large amount of cooling water necessary makes this plan too expensive in many localities, in which event the calcium chloride solution can be used, entailing small expense.

LOW TEMPERATURE DRYING.

Again, we have materials, such as photographic paper, which must be dried at a relatively low temperature all the year round. A temperature not exceeding 57 degrees F. is necessary or desirable. In cases like this no external air whatever is used except in cold weather. The air from the drying room is recirculated through the washer, in which the circulating water is cooled by refrigeration. The lowering of the temperature of the air condenses the excess moisture in it. In a recent installation this water entered the spray chamber at about 35 degrees. The air was reduced in temperature to 45 degrees, at which temperature it contains 3.4 grains per cubic foot at saturation. The air is then reheated to approximately 59 degrees when its percentage of humidity is 60. It is then returned to the drying room and the cycle repeated.

In connection with this last process it might be mentioned that a high degree of economy results from the fact that a back pressure of 45 pounds may be carried on the refrigerating machine whereas 15 pounds is usually figured for ordinary refrigeration. We also have a maximum of efficiency in the transfer of heat or cold between the water and the air, because of the intimate contact between the two. When we realize the condition that usually obtains in refrigeration work, with the frost covering pipes and cutting down the efficiency of the conducting material, the importance of this feature can be realized.

APPLICATION OF AIR WASHER AND HUMIDIFIER TO TEXTILE MILLS.

We have mentioned the application of the air washer and humidifier to textile mills. In plants of this nature constant and high humidity is of the greatest importance. In winter the heating of these buildings produces a dry and unfavorable condition. In summer the dry, hot weather, accentuated by the great amount of heat given off by the machinery, gives likewise an extremely dry and unfavorable condition in the mill. This extreme dryness prohibits the spinning of fine yarns, as well as necessitates a lower speed of the machinery, so that some artificial means to counteract those conditions is very necessary. The ideal conditions for a textile mill are indicated somewhat in the following table:

TABLE I. IDEAL CONDITIONS OF TEMPERATURE AND HUMIDITY.

Departments.	Temperature Degrees F.	Humidity Per Cent.
Spinning Room	75-80	60-75
Card Room	70-75	60-65
Winding Room	70-	75-80

It is seen that to obtain these conditions it is necessary to humidify in cold weather, and to cool in hot weather. The methods of humidifying we have already indicated in our paper, namely, by the use of circulating hot water in the spray chamber, controlling the same automatically by means of a thermostat. As a rule a large portion of the air in the mill is recirculated, only a small portion being taken from out of doors. In this way it is not necessary to add a great deal of moisture to the air after it is once at a suitable degree of saturation.

The problem of cooling in summer is perhaps more difficult than maintaining the high humidity in winter. It is possible to counteract the heat given off by the machinery in three ways, namely:

(a) Radiation—natural.
(b) Ventilation—natural or artificial.
(c) Evaporation—artificial.

While the greater portion of this heat is taken care of during the winter season by radiation, due to the difference in temperature between the room and the external air, in summer time it is necessary to take care of it by means of ventilation. To do this rapid air changes are maintained of from 5 to 6 minutes in the mill, the air being lowered in temperature by the absorption of moisture in the spray chamber, as we have previously mentioned.

It might be of interest to know that recently, with recirculated water in the washer, and by opposing the spray nozzles to the direction of the flow of the air, the air was cooled from 81 degrees down to 65 degrees. Of course this lowering in temperature is caused by the absorption of moisture tending to bring the air pretty nearly to the point of saturation. This cooled, humid air is then discharged into the mill where it is slightly raised in temperature, both by heat liberated from the machinery, and by the radiation through the walls, because of the higher external temperature.

With this system it is possible to keep all the windows in the mill closed. In fact, better results are obtained in that way. It is thus possible to eliminate the trouble experienced by draughts of air blowing in and breaking the fine yarns and causing endless trouble. By doing away with the old-fashioned method of having water dripping around the walls it is possible to entirely eliminate all free moisture from the air with its attendant rusting of machinery.

The following three tests will give some idea as to the closeness with which the ideal conditions can be approximated at varying outside temperatures. Two of these mills were located in North Carolina, while the third is in Hamilton, Ontario.

TABLE II. TEMPERATURE AND HUMIDITY TESTS.

Location.	Test No. 1.		Test No. 2.		Test No. 3.	
	Temperature, Degrees F.	Humidity, Per Cent.	Temperature, Degrees F.	Humidity, Per Cent.	Temperature, Degrees F.	Humidity, Per Cent.
Outside	51	31	48	95	34	62
Card Room ..	71	61	73	64	74	60
Spinning Room	80	70	79	70	79	66
Winding Room	70	83	71	86	—	—

Some idea as to the length of time this apparatus can be operated without any great personal attention is shown from the fact that after 2 weeks' continuous running, with a large portion of the air recirculated, but one nozzle out of 280 was clogged. When we think of the lint and foreign matter which is present in textile mills, it seems remarkable that such good results can be obtained.

B. T. U INSTEAD OF CANDLE POWER FOR GAS STANDARDS

The ordinace defining the quality of the gas furnished by the Dallas Gas Company, Dallas, Texas, provides that the gas "shall be a merchantable illuminating gas, as free of impurities, and as uniform in composition as is possible to be made, and of such quality that one cubic foot of the city gas, at 77 degrees Fahrenheit and 716 millimeters of mercury pressure, shall contain 650 British thermal units."

The reasons for the adoption of the heating rather than the lighting standard for gas are stated by Mr. J. C. Chisholm who investigated the subject and reported to the city officials. He says:

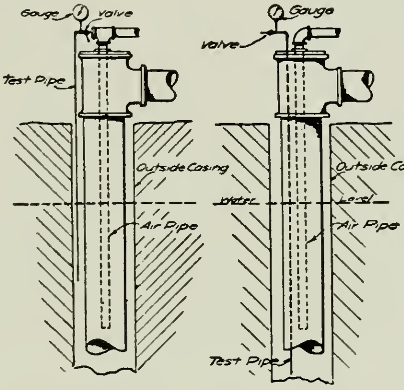
1. Candle power standards were necessary when gas was first manufactured and burned in fish-tail or jet burners; the olefines producing the light, which is therefore proportional to the percentage of these gases. The very extensive use of Welsbach lamps, however, has made it desirable to base the efficiency of the gas upon its heating power, since in these the light is given by the heating of the mantle to incandescence, wherefore heating power rather than direct light given is what is desired in modern gas. Moreover, 90 per cent. of the gas at Dallas is used for fuel purposes, for which light-giving properties are considered as of no value, and consequently heat units form the natural bases for measurement.

2. It is possible, by using producer gas or semi-water gas, to make a gas that may be 18 to 22 candle power and yet contain not more than 450 to 550 British thermal units. Coal gas, carbureted water gas and oil gas, as manufactured by the majority of our cities, contain 650 to 680 British thermal units; furthermore, it is impossible to economically manufacture a gas containg 650 British thermal units without requiring sufficient carbureting material to produce a gas of 18 to 22 or more candle power.

3. The ordinance also requires the price of 1,000 cubic feet to be prorated, if the number of British thermal units fall below 650 for a month's average.

COMPRESSED AIR FOR MEASURING DEPTH OF WATER

In a paper by Mr. Charles B. Burdick, before the Western Society of Engineers, the device shown in the sketch is described and is said to have been in use ten years or more. There is simply a small pipe say ¼ inch, and a pressure gage reading to single pounds or less. A pipe of sufficient length, the length being known, is lowered into the well and air pressure is then applied until the air escapes from the lower end and consequently the pressure at the gage will rise no higher. The reading of the gage in pounds multiplied by 2.304 will give the height of the water in feet above the submerged end of the pipe. The cut shows the arrangements in connection with an air-lift. The left hand figure shows a case where the exterior of the water pipe is accessible. Upon an air-lift when this can be done the compressed air can be obtained by tapping the air pipe. The right hand figure show an application to an air-lift where there is no room outside, and with this arrangement a hand air pump is desirable, as the pressure required in the test pipe is a little in excess of that in the air pipe. The ordinary beer pump or large bicycle air pump answers this purpose nicely. Applied in this way the lift can be measured readily, even when the well casing is used as a discharge pipe.



FOR MEASURING DEPTH OF WATER.

FOR ENGINEERING EXPERIMENT STATIONS

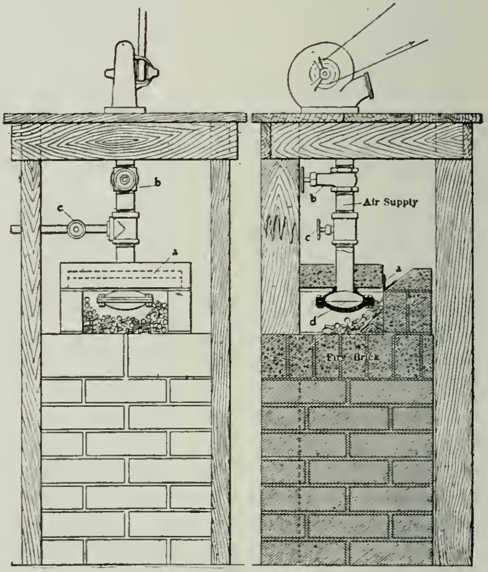
A bill has been introduced in Congress for the establishing of engineering stations, the purpose of which will be to conduct original researches or to verify experiments which relate to the properties of materials employed in manufacturing, building, and constructional operations; the properties, physical and chemical, of fuels, fluid media, lubricants, and other substances or materials used in the generation or transmission of power; the efficiency and economic value of mechanical devices; the generation, transmission, and utilization of electrical energy; the engineering problems connected with transportation; the provision of suitable water supply for domestic and manufacturing purposes; the disposition of industrial, household, and city wastes; the engineering problems connected with public utilities; the economic methods of mining and preparation of ores and other mineral products; the methods of prevention of waste of all natural resources whose use is related to the science of engineering; and such other researches or experiments bearing directly upon the application of the mechanic arts and science of engineering to the industries of the United States.

To endow and maintain these engineering experiment stations, Congress is asked to make an appropriation of $30,000 annually, to be paid to each state or territory. Out of the first five annual appropriations received by any station an aggregate amount not exceeding $30,000 may be expended in the erection, enlargment, or repair of a building or buildings necessary for carrying on the work of such station; and thereafter an amount not exceeding 5 per cent. of such annual appropriation may be so expended. These experiment stations may be established at any of the state schools, but unless definite action is taken by the state the privilege and appropriation would go to the land grant colleges.

It would seem that much more could be accomplished in the direction indicated by the concentration of the expenditure upon a single National institution. Better men could be employed, more systematic and comprehensive courses could be laid out and followed, more usable and accessible records could be kept, and there would be no wasting of time and effort in the simultaneous pursuit of the same lines of experiment and investigation at several stations. The expenditure which must seem quite inadequate for any state, would be a handsome and quite adequate endowment for a single plant. To spread the money as proposed would be practically to throw it away.

GAS FURNACE FOR HEATING RIVETS

The sketch shows a simple furnace for heating rivets. The setting is substantial and can be installed at a slight cost, the largest item being the small fan for the blast. The air supply for the 12-inch fan can be regulated by means of the valve *b*. The gas enters through valve *c*, which acts as a medium of control. Air and gas combine in the lower part of the air pipe and in the burner *d*, from which it issues in a downward direction. The fire box is constructed of fire brick and has an open front, also a small opening in the rear, which is covered by the V-shaped plate marked *A* in the sketch.



GAS FURNACE FOR HEATING RIVETS.

The rivets are dropped through this latter opening and roll down the inclined inner rear surface of the furnace to a position under the burner. They can thus be fed in gradually; as the flame can be controlled to give the proper temperature, the rivets can be heated to the proper degree without danger of burning them, as often happens in a hand forge.

No special attendant is required to watch the rivets after the flame is once adjusted. This furnace has been in operation for some time, giving entire satisfaction.—*American Machinist.*

A LONG DRAINAGE TUNNEL

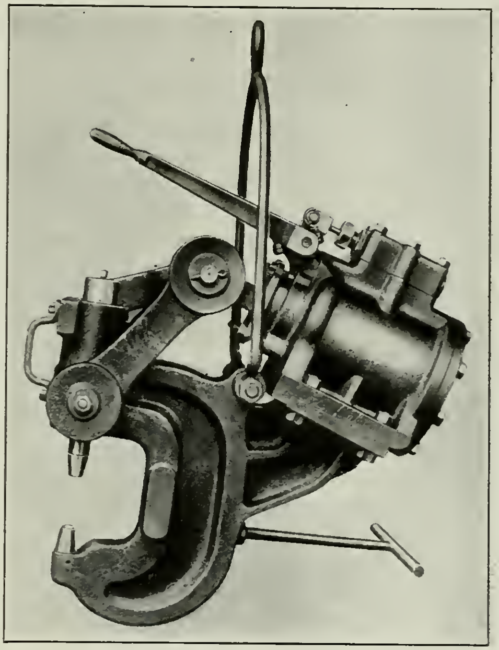
The deep drainage tunnel projected and financed by the mining corporations of the Cripple Creek district, has been driven to date approximately 1,250 feet, leaving 14,300 feet to be covered before the main water channel is tapped. The bore, destined to become the all-important factor in the great gold camp's future was formally commenced on May 11, 1907. The work, however, has not progressed as rapidly as anticipated and two contracts have been declared forfeited. Work has not even temporarily ceased, as, until a new contract shall have been let, the Cripple Creek Drainage and Tunnel Company is continuing the work. The contracting parties will be required to drive the bore 750 feet each three months, until the intermediate shaft is completed to the tunnel level, when the driving of the bore must be carried on at the rate of 1,500 feet, as the work will then be prosecuted from three distinct headings. The conditions required for the sinking of the intermediate shaft call for the sinking of 200 feet each three months. The depth of the tunnel shaft to the tunnel level is 880 feet, and 100 feet of sinking has already been accomplished.

A NEW PORTABLE PNEUMATIC COMPRESSION RIVETER

Perhaps in few lines of apparatus is the economy of the pneumatic device for the service so pronounced as in the case of the compression riveter. We need not to be reminded of the time and the cost of hand riveting; as to the pneumatic compression riveter it is very near the truth to say that it takes no time at all, inasmuch as the actual time occupied in driving any considerable number of rivets by pneumatic compression is consumed in moving the work when the riveter is stationary or in moving the riveter when the work is stationary.

The riveter here shown has a record of having driven 12,000 rivets in 10 hours. The work was on a long plate girder, and the riveter was suspended from a trolley on an overhead runway. The operator had become very expert in moving the machine from one rivet to the next, the spacing being equal, the plates of uniform thickness, the rivets all alike 3-4 inch diameter and several heater boys keeping the holes ahead of the riveter constantly full of hot rivets. The dies were replaced by cool ones at intervals during the progress of the work.

Under similar conditions another record was made of 10,000 rivets in 10 hours time. These figures, of course, are of interest as showing what has actually been done, but the type of work should not be forgotten. On boiler work, where the rivet must be steam tight, no such record could possibly be made, as more time would be consumed not in the riveting but in securing the joints properly together in advance of the riveting. The records speak clearly, of the facility and rapidity with which the riveter as such can be manipulated and operated.



ALBREE PORTABLE COMPRESSION RIVETER

This riveter, built by the Chester B. Albree Iron Works Company, Allegheny, Pa., has a 6-inch reach, will drive a 7-8 inch rivet and weighs 850 pounds. The rivet compression is effected not by the direct pressure of the air but by the action of levers which give much greater force when the final squeeze occurs, thus enabling a small cylinder to be as effective as a much larger one would be under the primitive arrangement and securing the best economy in the use of the air. When desired this machine may be equipped with the maker's universal bail which will hold it suspended and in perfect balance in any position. The use of portable riveters is being rapidly extended and is promoted by the putting out of such apparatus as here shown.

A COMBINATION POWER PLANT

The various and novel combinations of power generating and power utilizing apparatus, now frequent, illustrate at once the independence and the resourcefulness of the modern engineer. At Pittsfield, Mass., the main station of the electric company is a coal burning, steam driven plant not strikingly different from many others of the present day. An outlying auxiliary station, however, is built and operated upon such different lines as to appear to be hardly of the same family.

The building, to begin with, is up-to-date, in that it is built of concrete blocks made by a machine on the spot. There are three 6,000 gallon tanks outside the building, and these are filled with fuel oil from railroad cars which run alongside. The oil is allowed to flow by gravity into the basement and then is pumped as required to two small tanks in the engine room. Here are two three-cylinder Diesel oil engines, having a common shaft with a 350 kilowatt alternator on the middle of it.

The Diesel engines are four cycle, but in other respects have special characteristics of operation. For each cycle a full charge of air is compressed to above the igniting point of the fuel, which is injected in quantities graduated according to the varying power requirements, and is burned, not exploded, under controlled conditions of temperature and pressure. The cylinders are 16 x 24 inch and each engine is rated at 225 horse power. Connected with each engine is a three-stage belt driven air compressor which delivers the air at a pressure of 1,000 pounds. This air is used not only continuously when the engines are running, but its pressure is also available for starting the engines and getting them up to speed before the oil combustion cycle is established. With each engine there are six air bottles, two of which are connected constantly with the air pipes as additions to their capacity to minimize the fluctuations when the engines are running, the other four bottles being kept charged to be always ready for starting. A motor-driven triplex pump is another element of the active service, thus using water from a neighboring lake and circulating it through the jackets of the air compressors and especially of the engine cylinders.

USE AND ABUSE OF HOT AIR

The following is a portion of a talk by Mr. C. A. Burgess at the recent annual convention at Toledo of the Ohio State Stone Club:

You all well know we have been preaching to you for years against the habit of compressing hot air. It is quite as bad as listening to it. Hot air should never be compressed, for it is a costly practice. You lose at both ends of the line by compressing hot air, you do not get the full efficiency of the compressor nor of the machinery driven by the air after the compression. Hot air is all right in its place, but its place is not in a compressor room for compressor purposes.

Hot air is an excellent embellishment in conventions and banquets. It is also an excellent tonic to use next morning in the Turkish bath after attending the conventions and banquets. How much we appreciate those heat waves the morning after, when we find ourselves chanting that little poem:

Heads of great men all remind us
If we go the proper gait
We may get up in the morning
With a head that's just as great.

We know that that "greater" effect is produced by an "after" effect and that invariably the "after" effect was produced by our separating ourselves from a generous portion of our personal effects.

While I do not believe the report, yet I have heard of instances where generous portions of hot air have been used by the quarrymen and road-builders in securing valuable crushed stone contracts from county commissioners, and not until they woke up and found that the county commissioners had been just as foxy and had used the same stuff in framing their contracts did the quarrymen and road-builders consider the practice a foolish one.

Did you ever attend a letting when every surrounding and every condition made you think you were at your home county fair and that everybody had patronized the toy balloon man? There would be forty-eleven contractors and quarrymen present, each with an estimate or proposition so inflated with hot air prices as to make it appear more like one of those variegated colored rubber bubbles than anything else.

It is only the frequent indulgence some contractors take in making hot-air estimates that allows us—the manufacturers—to sooner or later discover that our contract forms also contain hot-air germs. That portion of our contract forms which reads "30 days net" really means "30 days *nit*." It is then we do a little damage ourselves, and our finance department at the home office in New York goes us one better and simply raises—well, they pass it back to us in an even more heated condition. Then we pass it along in an equally hot condition to the party whose autograph decorates the rear section of the contract. Then he hands it back to us just a little hotter, and with just a little redder glow, and before we know it we are all raising little hells of our own.

Hot air is a dangerous thing to use in business deals, for it will surely burn up the bank account in time. Good, honest competition never did hurt anybody and never will hurt anybody. The only time we ever have occasion to spell the word "stung" in capital letters is when we get out our hot-air salve and attempt to use it on somebody or allow somebody to use it on us, or, worst of all, when we try to use it on ourselves.

When we expect to gain favors we are not entitled to we are certainly monkeying with the hot-air tank. When we fail to value honesty in our business transactions, both with our customers and ourselves, we have got the hot-air valve open again. When we fail to place a commercial value on our work or our products commensurate with what they are actually worth we have got the hot-air safety valve tied down.

The White Cliffs field in New South Wales, Australia, has produced opals to the value of $5,000,000. The field was discovered by hunters while endeavoring to track a wounded kangaroo.

AERONAUTICS AND THE ELECTRICAL ENGINEERS

At the meeting of the New York Electrical Society held in the Engineering Society's Building, Feb. 28, an interesting lecture was given by Mr. Augustus Post, the well known aeronaut, on "Navigating the Air." Perhaps a disproportionate volume of the address was given to the too familiar balloon, which was described with all its appurtenances in minute detail. A practical illustration of an ascension was given by the inflation of a model balloon perfect in every detail loaned by Mr. Albert C. Tridca, director of the International School of Aeronautics. Following the balloons proper came the motor driven and dirigible balloons of various types and then the heavier than air class. These were divided into aeroplanes, including kites, gliding machines with and without motor, and machines of the helicopter and ornithopter types. Of these two the former are direct lift machines, using propellers to lift them into the air while other propellers cause them to move forward, or the machine is tilted so that the lifting propellers also cause horizontal movements. Ornithopters, as the term suggests, are bird like with flopping wings which have not as yet shown much promise of success. Many striking episodes of the Gordon-Bennett balloon races at St. Louis were shown in moving pictures in which were seen the inflation of the enormous bags under the direction of a special detachment of the U. S. Signal Corps, then came also the actual start, the ascension and the shrinking of the balloon to a mere speck in the sky. A series of interesting slides was shown by Mr. Wilbur R. Kimball, a large number of slides being loaned by the Aero Club and by Mr. W. J. Hommer.

A PNEUMATIC DESPATCH EXHIBITION

The Pneumatic Transit Company upon the recent formal opening and adoption of a considerable extension of the postal pneumatic tube service in Philadelphia made the occasion an effective demonstration of the working of the system. About 200 invited spectators gathered at Station C, Nineteenth and Oxford streets, and saw the station transformed into a department store.

Hot tea, coffee and chocolate: roast turkeys and other dishes; cakes, pastry, fruits and the dishes on which they were served to hundreds of guests; aquariums of gold fish, a chattering monkey, pigeons, cats, guinea pigs and animals, and articles of every description which could be snugly held in a steel tube measuring about thirty inches in length and nine inches in diameter, were ricochetted from one station to another terminating at Oxford street. A lighted candle encircled the city without becoming extinguished. None of the living things suffered from the experience.

From the main post office at Ninth and Chestnut streets each tube goes to Station O at Tenth and Columbia Avenue, thence to Station S at Sixth and Fairmount, to the Pennsylvania Railroad Station, to Station J, Nineteenth and North, and then along the last lap of the subterranean journey to the terminus at the Oxford Street Station.

THE LIMITATIONS OF AERIAL NAVIGATION

There is a good deal of misconception as to the probable field for successful aerial navigation. To the lay mind anything is possible, and the "navies battling in the blue" appears a reasonable probability of the future. The engineer, however, realizes the inherent dangers and difficulties of any form of air navigation. No invention or ingenuity can neutralize the danger to a body poised in mid air and dependent only upon the supporting power of the air to save it from a disastrous fall to the earth. No invention or ingenuity can make safe the navigation of a medium subject to such commotions as hurricanes and tornadoes. By no possibility can carriage of freight or passengers through mid air compete with their carriage on the earth's surface.

The field, then, for aerial navigation is limited to military use and for sporting purposes. The former is doubtful; the latter is fairly certain. As regards the former, it will be recalled that military balloons have been in use for more than half a century; and that modern high-power, long-range guns have greatly limited the usefulness of such methods of observation. There is every reason to believe that the same thing will limit the usefulness of the military dirigible balloon or flying machine. As for the use of any form of aerial navigation for carrying messages, the development of wireless telegraphy and telephony appears to have blocked all prospect of success there.

The sporting field is therefore the real field at which the flying machine inventor is aiming. Already ballooning and driving dirigibles are among the most popular fads of the sporting set in Paris. Aside from this the imitation of the birds has fascinated thousands and millions of people to an extent that makes it certain that the search for a successful flying machine will go steadily on, even though there be no prospect of great commercial returns to the inventor.—*Engineering News.*

A FORTUNATE SOCIETY

An esteemed contemporary announcing the results of one of the annual elections says:

The gentlemen named above are all eminently fitted to be officers of the American Institute of Mining Engineers. No better engineers are to be found than those mentioned, while the councilors are men of standing and prestige.

It should not be forgotten, however, that Dr. R. W. Raymond is the man who has made the Institute what it is. Through thick and thin, through good times and bad, in sickness and in health, Dr. Raymond has given his time and his intellect to the upbuilding of the Institute. It is his brain that makes the Transactions a standard of modern science; his personal magnetism that induces men to contribute gratuitously to the Institute material which they could sell elsewhere for much money; his power of management that has kept the Institute together, nipped in the bud all factional differences, and brought it from a small society to the front row of the technical societies of the world. For the last five years Dr. Raymond has been much afflicted with sickness; for weeks at a time he has suffered the most excruciating pain. Notwithstanding this fact, his zeal for the Institute has never lagged. He has done much of his work in bed, but the work has been done. Why is it that almost every great human accomplishment succeeds only by sapping some man's lifeblood? That every deed worth doing is done in spite of pain or loss or hardship?

COMPRESSED AIR
AND EVERYTHING PNEUMATIC
Established 1896

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NEW YORK'S COMPRESSED AIR HARVEST

Probably never was such a marvelous harvest as that which the city of New York is just now realizing from its compressed air plants. We speak now only of one group of these plants, the eighty air compressors which have been employed exclusively in subfluvian work and which have averaged much less than a decade of active service, and yet there are now six tunnels under the Hudson River and eight under the East River, all but two of which have a connected bore from shore to shore and four of which have been crowded with a continuous traffic from the days of their recent respective openings to the public, though neither has its completed traffic connections. The completion of each tunnel at once emphasizes the necessity for more, so that nothing is perhaps more certain than that numerous other tunnels will soon be under way, each upon completion to be immediately filled with the rushing currents of the city's life.

The first important compressed air plant, from which New York enjoys a perennial harvest was of course the New Croton Aqueduct. What could we do without it and how could we have had it without the air driven drills? Then there was the East River gas tunnel, the importance of which as a pioneer and educator in that line of work is not generally recognized, which more than justifies the sketch of the progress of the work which we present in our present issue. Here the compressed air, which was started in good faith merely to drive the rock drills, soon was saddled with a more serious and responsible function, that of opposing the pressure of the water, this double function since prevailing in all the subsequent tunnel work. Then came the subways, which, like the tunnels, all make the public immediately clamorous for more. In all these works compressed air has been the most conspicuous and responsible agency of construction and must continue so as long as we are permitted to see into the future. If anything may be said to be sure of constant employment anywhere it must be compressed air in New York.

A TYPICAL INVENTION

The initial act in the invention of the electric air drill, the first recognition or apprehension of the essential mechanical principle of its operation, would seem to have been a simple and easy thing, not that the simplicity of such an achievement, as regarded after the fact, in any way predicates the likelihood of its early accomplishment. All through the ages we have waited so long for the simplest things which we have been surprised with when they have appeared, and even then have been slow to appreciate them fully.

The realization of a novel invention is not unlike the catching of a fish, which is a simple enough trick, only that we have to wait, alert and prepared, until the fish comes along; and then the true fisherman's skill is not in getting the nibble, or even a bite that holds, but in landing the fish securely into the net of practical realization. The catching of a fish does not seem to typify the entire operation of successful invention satisfactorily. The patient working out of all the details of adaptation and practical employment, so that the new apparatus shall show decided advantages over all its predecessors, is quite another and a more protractedly laborious work than the first secure grasping of the idea.

In fishing for inventions, each catch is different from all which have been caught before, and after the capture many things remain to be learned, both those which have preceded it and those which will come after it, as one thing always leads to another. Each notable mechanical invention has been essentially a simple one in itself, but the study and development of its relations and adaptations have always employed many keen wits besides that of the so-called inventor.

At first it might be wondered why the plodding and faithful steam or air-driven rock drill should have been interfered with, and how a device so different in some of its essentials could possibly develop any advantages. In the first place, it may be hastily and honestly argued that the new electric air drill is a complicated arrangement as compared with the simple old rock drill. When the thing is looked into this objection becomes a self-evident absurdity, and the new device is a great simplification and effects a great reduction in the size and number of responsible parts. The drill itself has been reduced to its simplest terms and to the fewest parts; all the details of the old drill most complicated, most responsible, most trouble-begetting, most costly of maintenance, have been discarded, with no equivalent devices taking their place. The old drill implied a steam boiler or an air compressor, more or less distant, always entailing great losses in power development, and a costly pipe line to install and maintain and to extend as the work progressed. The new drill is complete in itself, carries everything with it, and its only connection is the electric wire, through which it asks for only one-third to one-fourth of the power formerly required to do the same work. In the actual doing of its legitimate work the new drill asks no odds of the old in any detail of its operation. It strikes a sharper, heavier blow, and more blows per minute. It solves completely the problem of employing the electirc current in rock drilling. That it will, therefore, soon knock out the steam or air drill is not to be expected, but that it will be making its way on its merits and that it will be taking the lead in new installations seems natural.

Like all new things, the electric air drill must at first be misunderstood and more or less misrepresented, often with honest intent by those who are not sufficiently or correctly informed. It is well worth investigating as a novelty and for its intrinsic worth.

A SPECIAL EDITOR FOR A. S. M. E. PROCEEDINGS

The American Society of Mechanical Engineers is rising to its opportunities, widening its field of usefulness, and augmenting its status as a national society, its latest important move being in the extending of the scope of its published proceedings. These have lately been taking the shape of a regular monthly periodical and now the publication is to have a recognized and responsible editor, in the selection of whom the society is to be heartly congratulated. Mr. Lester G. French has been appointed and has already entered upon his duties.

Mr. French was born in Keene, New Hampshire, in 1869, and very early commenced his training in editorial work and printing at Brattleboro, Vt., his father having been the publisher for a very long time of *The Vermont Phoenix,* and a partner in a large printing establishment in that place. In 1891 Mr. French received his degree in mechanical engineering from the Massachusetts Institute of Technology. After four years apprenticeship, drafting room and shop experience, principally at the Builders' Iron Foundry shops in Providence, and a year and a half as a text book writer, Mr. French was engaged on the editorial staff of *Machinery,* assisted greatly in the development of that paper and for nine years was its editor-in-chief.

Among the immediate improvements to be undertaken is the establishing of departments in the monthly Proceedings, thus providing a greater variety of technical articles of interest. Many other features are planned and the aim will be to make the Proceedings of such value that no engineer can afford to be without them. All such papers, however, will first be presented and discussed before the Society at its meetings, as formerly, thus benefiting the membership two fold.

CORRESPONDENCE

COMPRESSED AIR LEAKAGE

Editor Compressed Air.

I have something on my mind. I have before me a copy of the first issue of *Reactions,* which is an attractive and valuable quarterly publication put out in the interest of the Goldschmidt Thermit Process of Welding. I want to give first some extracts from one article in it relating to compressed air transmission. It says:

"Few people realize that leakage plays an important part in the efficient operation of a compressed air plant. Many concerns will go to great expense in installing high class air compressors with compound steam cylinders and two stage air cylinders, but when it comes to installing the pipe line the utmost carelessness is displayed, the same fittings being used that would apply to a steam line without the fact being taken into consideration that steam and air are two very different mediums. The heat of the steam tends, of its own accord, to keep joints tight which if cold, would leak considerably."

The writer then goes into figures, considering successively the large central power plant, the plant of medium capacity, say for mines and quarries, and the small plant for manufacturing establishments. Of the first he says:

"This plant, while often very much larger, we will consider to have a capacity of 10,000 cu. ft. of free air per minute and assume that there is leakage of 1 per cent. or 100 cu. ft. of free air per minute. The horsepower required to compress 100 cu. ft. to 100 lbs. in a two-stage compressor would be 17.6 (allowing 15 per cent. for friction in the machine). Considering the cost of this power to be 2 cents per horse-power per hour, the cost of the leakage will be 35.2 cents per hour, or $3.52 per ten hour day, amounting to $1,056 at the end of the year of 300 working days. Even if the leakage only amounted to one-half of 1 per cent., the loss would come to over $500 per year."

The medium plant is similarly assumed to have a capacity of 1,000 cu. ft. of free air per minute and with a leakage of 1 per cent. as before the loss would be 35 cents per day or $105 per year. Now for the manufacturing plant:

"The plant is most frequently of a capacity of about 500 cu. ft. of free air per minute, but the percentage of leakage should be figured a little higher than in the previous plants, owing to the fact that more pains are taken with the larger and more expensive plants in the installation of machinery and piping than is the case with smaller and cheaper plants. Furthermore, most manufacturing establishments require a more complicated distribution of the compressed air and the installation of more valves, bends and outlets is needed. It is therefore more fair to consider the leakage as being 2 per cent. in these cases. The compressor will very likely be a single stage one and the horsepower required to compress the leakage of 10 cu. ft. per minute to 100 lbs. pressure will be 0.207x10=2.07. At 2 cents per horsepower per hour this leakage would cost 41.4 cents per ten hour day, or $124.20 per year."

The animus of this appears in the last sentence of the article:

"It is to counteract these losses that many concerns are now butt-welding the pipe joints in their compressed air and refrigerating pipe lines, thus producing a continuous line of pipe in which leakage is entirely impossible and the cost of maintenance eliminated."

Now, as to the loss by leakage. I have reason to believe that the above assumptions are exaggerations and that it is not so difficult nor so unusual as here represented to make piping airtight. The capacity of the usual air receiver represents about one minute's output of the compressor with which it is associated, and the piping capacity will not average any more than that of the receiver, or altogether it might be said that two minutes' working of the compressor would fill the entire system from atmosphere up to full working pressure, and then when the compressor is stopped at night and in the morning the air pressure is still found there, which is the not infrequent occurrence, it is easier to realize how little air has leaked away than how much.

A handy, cheap and reliable welding process, which Thermit undoubtedly is, would, for compressed air practice, need to be accompanied by an equally handy, cheap and reliable *unwelding* process, for *all* air piping is not permanently installed, and the butt-welding of straight piping would not in any case eliminate the possible leakage, which occurs not in the run of the pipe but in valves, stuffiing boxes and other places where Thermit would not apply.

TECUMSEH SWIFT.

Editor *Compressed Air:*

In looking through your very interesting journal for February, my attention was attracted by the description of Mr. W. C. Stephens' double-edged chisel bit, and I note with considerable surprise that this gentleman is referred to as having introduced the "now indispensable hollow drill bit."

It may be a matter of interest to the writer of the article that hollow drill bits were in use nearly thirty years ago, and I have before me now the British Patent Specification of C. Pieper No. 22589 of 1879 in which the hollow steel bit and a delivery of water under pressure right through the drill from the back head forms an important item of the patent.

J. H. WETHERDON.

[The statement referred to was given upon the authority of the *Mining Journal,* London. —Editor COMPRESSED AIR.]

QUESTIONS AND ANSWERS

L. T., Providence, R. I., Q.: I have a gasoline engine about 4 H. P., single cylinder, two cycle, the cylinder 4-inch diameter by 4 1-2 inch stroke, with 80 pound flywheel. I wish to compress air on a small scale but to a high pressure, say 2000 pounds, and I am thinking of placing the compression cylinder, oc cylinders, directly behind the engine cylinder with one piston rod for all. I believe the working pressure of the engine would average about 70 pounds for the stroke, would it not? My question is as to the size of the compression cylinders. I suppose at once you would say in such small powers use a single cylinder, but it seems to me that with such high ultimate pressure, requiring a very small cylinder, that a secondary larger cylinder would facilitate the handling of more air. What should be the sizes of the two cylinders, and what should be the size of the single cylinder, if you decidedly think that one cylinder should be used? A: we decidedly think that not less than two cylinders should be used and three would be better; but the scheme as outlined has even then several elements of impracticability. The engine at 400 r. p. m. and at the 70 m. e. p. assumed for the working stroke would not show more than 3 brake horse power. With a piston rod carried out through the combustion chamber what kind of stuffing box and what packing would it be possible to use in the back cylinder head? The speed assumed would be high for such compression, but not perhaps impossible. An intercooler between the two stages of compression would be absolutely necessary and the arrangement as a whole would be so objectionable that it is not worth while to compute any cylinder sizes. Better leave the engine alone if it is all right and have a suitable belt driven compressor to go with it.

W. W. M., Pittsburg. *Q.*: I have prospective use for a pair of compressed air motors about as follows: 50 H. P. at 600 R. P. M., for continuous service in a coal mine, the load varying from 30 to 50 H. P., speed regulation to be within 10 per cent. and the motors to be entirely enclosed and self-lubricating. The less the space occupied the better; no reheating possible. I have at hand Mr. Richards', Mr. Hiscox's and Mr. Saunders' books on Compressed Air, but in neither of them can I find anything near the above requirements or any data relating to the air consumption of well-built motors in the above sizes. From the mass of compressor advertisements, and the amount of space devoted to the production of compressed air in the various books on the subject, and the corresponding lack of information on the motor end of the problem one is naturally led to suppose that compressed air for the production of rotative motion is not in extensive use.

A.: The simple fact is that a steam engine makes such a perfect air motor that the compressed air people have no excuse for exploiting anything special for that purpose. You need a steam engine of suitable size with automatic cut-off governor, such an engine, for instance, as commonly used for electric lighting, and you will find that the engine will work better with air than with steam, and, of course, should regulate far within the 10 per cent. required. The tables in Richards' Compressed Air under "Power Value of Compressed Air," should give you all the data required for your computations. Use thin, limpid, *oily* oil, not as heavy as recommended for air compressors, and the lubrication will be found to be much better than with steam, as the oil remains on the surfaces much longer.

TRADE PUBLICATIONS

Steam Turbine Machinery. De Laval Steam Turbine Company, Trenton, N. J. 30 pages, 4½ by 7 inches. Numerous half-tones.

Shop Instructions for the Use of Thermit in Repair Work. Goldschmidt Thermit Company, New York, 32 pages 5 x 8 inches. Very complete detailed instructions are given with descriptions of apparatus required, quantity of material to be used, etc.

Steel Tires—Causes of Defects and Failures. Standard Steel Works Company, Philadelphia. 38 pages 6 x 9 inches. This is a reproduction of a paper by George L. Norris, read before the Western Railroad Club with the discussion which followed and an editorial upon the subject from the *Railroad Gazette*. There are numerous fine half-tones showing fractures, etc.

Locomotives Built for the C. R. R. of Brazil. Record No. 64, Baldwin Locomotive Works, Philadelphia, 32 pages 6 x 9 inches This describes the railroad system of Brazil and the various locomotives built for it by these works. The first locomotive was furnished in 1862, and up to date 326 have been built, their types representing the increasing demands of traffic and the successive improvements in design. Many of the engines were "narrow" or meter gage, but the larger number and for the principal lines were five feet three inches. It is intimated that a considerable business is realized by the works in supplying duplicate parts for the maintenance of this equipment.

PRACTICAL REFRIGERATION WITH A COMPRESSED AIR MOTOR

Revue Industrielle describes an interesting and profitable installation of an air motor in connection with a brewery in Paris, the public compressed air service, which is maintained in that city, being used to drive the motor for electric lighting purposes, and the exhaust being used for refrigerating with such success that the power and light service costs practically nothing.

The motor used is an old steam engine with early cut-off, the cylinder, built to metric measures, being 17.7 inches diameter; the stroke, 35.4 inches, and the normal speed 58 to 60 revolutions per minute. The engine has an unusually large exhaust pipe, 7 inches in diameter, so that its choking by freezing is thus avoidable. The motor drives a dynamo giving 300 amperes at 110 to 115 volts, which is capable of supplying 45 arc lamps, and 50 to 400 incandescent lamps, 10 to 16 candle-power. The motor runs 7 to 8 hours in summer and 10 to 12 hours in winter. It receives the air at 71 lbs., and at a temperature of 53 to 60 degrees Fahr., developing usually about 30 horse-power, which on Sunday may go to 40 or 45 horse-power. Glycerine is used for lubrication, its presence in the air being less objectionable than that of oil.

The theoretical difference of temperature between admission and exhaust would be about 176 degrees, and the exhaust actually goes as low as—76 degrees, Fahr. The lowest temperatures reached are, of course, in the winter, and after long continuous operation.

The exhaust pipe is passed through the basement, discharging into the freezing chamber toward the bottom of that room. This chamber is divisible into two parts by a movable partition, and the part receiving the exhaust directly is the freezing compartment, while the other is used for storing ice. The walls, ceiling and floor of both compartments, as well as the exterior wall of the beer cellar, are made of blocks of ground cork covered with wood sheathing. The freezing room and the ice storeroom are each 9.8 feet long, 14.75 feet wide, and 5.75 feet high. The beer cellar is designed to hold about 2,650 gallons of beer in barrels.

The exhaust pipe expands from its general diameter of 7 inches to a diameter of 15¾ inches in the wall of the freezing chamber. The water for freezing is placed in cans containing 22 pounds each. The air for cooling the beer cellar passes from the freezing room in a pipe 15¾ inches in diameter and extends some distance within that room. In the passageway separating the cellar from the freezing room a subdivision is made in this pipe, one branch going to the cellar and the other connecting with a riser pipe discharging to the atmosphere. A butterfly valve is inserted in both branches for regulating the air supply to the cellar, so that it is possible to vary the volume of cold air passing into the cellar according to the needs by by-passing a portion of the total flow to the atmospheric discharge.

The utilization of the exhaust from the compressed air motor which drives the lighting unit thus furnishes both ice and cold which it would otherwise be necessary to purchase. The compressed air costs at the rate of 4.45 cents per 1,000 cubic feet, and the consumption per horse-power is about 847 cubic feet. The net cost per kilowatt-hour under these conditions amounts to 6.3 cents, indicating an efficiency of nearly 80 per cent. for the machine. Ice costs 44.7 cents per 100 lbs. It is stated that for cooling the cellar 0.415 pound of ice would be required per gallon on the basis of 7 hours operation in summer, or 1,100 pounds for the 2,650 gallons of beer which it holds. This means 157 pounds would be required per hour. The production of ice per horse-power per kilowatt-hour amounts to 14 pounds. This means that when the lighting unit is supplying 300 amperes, or in other words an output of 34.5 kilowatts per hour, that the ice capacity is 485 pounds in one hour. The cost of this ice at 44.7 cents per 100 pounds is $2.17. The cost of the compressed air at 6.3 cents per kilowatt-hour for the 34.5 kilowatt-hours amounts also to $2.17. This indicates that the lighting service costs nothing, the unit supplying an amount of ice that would cost if purchased what the compressed air actually accepted did cost.

MISLEADING EFFICIENCIES

It is unfortunately true that the word "efficiency" has not so definite a meaning as we might hope. Ordinarily the word implies a ratio between the measure of an effect and a cause. It may be the ratio of the energy delivered in the form of useful work in foot-pounds to the energy supplied in the same form at a shaft, or to that supplied in the form of water under pressure, in the form of heat in steam, or heat in coal. The useful effect may not be measured in foot-pounds, but in some other unit subject to just as great variety in the form of expression as the energy supplied. Quite as often, however, is the word applied to the ratio of useful effect not in the form of energy to some unit of supply. Thus, in ice making plants the weight of ice produced per ton of coal is often used as one measure of the efficiency of the plant, but it by no means represents the thermodynamic efficiency considered of the ratio of the energy abstracted from the system to the energy supplied. In blast furnace practice the ratio of the weight of iron produced to the coke supplied, and with excavating machinery the weight of coal used per cubic yard excavated, might be cited as measures of efficiency that are not energy ratios, though perhaps involving them.

In still another sense is the word efficiency used; as the ratio of values or weights or other quantites; thus for pumps, the ratio of the volume of water pumped to the piston displacement; and in compressors, the ratio of the cubic feet of gas or vapor at the suction pressure to the piston displacement, are examples of volumetric efficiency entirely independent of the energy employed. The efficiency of a business might be, and is often measured by the earnings. Quite frequently, though loosely, the efficiency of a man is a matter for consideration, implying, when so used, the mental comparison, consciously or unconsciously, and his accomplishments in some line of work with those of other men similarly employed, as his general effectiveness.

Efficiency is sometimes used in this general sense of effectiveness without implying a ratio of effect and cause at all, but rather implying a unit of capacity. Thus, the efficiency of heating surface is often referred to, but what is meant is the capacity of that particular surface for transmitting heat. It seems rather unfortunate, therefore, that a purchaser or even an engineer should be led to believe that so indefinite a word or term is employed as an element in the judgment of the value of machinery. Any purchaser of machinery is essentially an investor of capital who expects to make money by supplying some market with a commodity, in the production of which machinery plays but a part. For such a purchaser, or plant owner, one style of machinery is better than another only when the cost of its operation is less per unit of product, that cost being properly computed, and including the cost of all raw material for operation directly and indirectly for repairs and maintenance, together with the labor for operation, maintenance and superintendence to give the total operating cost. To this is to be added the fixed charges, involving interest and depreciation, insurance, taxes, and in the case of interruption to business by breakdowns or losses of capacity, a sum in the nature of damages or deferred profits. It makes not a particle of difference to such an owner of an ice or refrigerating plant whether his steam engine has a thermal efficiency of 5 per cent. or 10 per cent., or his boiler 60 per cent. or 70 per cent., whether his compressor has a volumetric efficiency of 70 per cent. or 100 per cent., provided the cost of his product, which is not steam or gas power or pumpage, but ice or refrigerated rooms, be properly low.

The commercial value of machinery is, therefore, not to be found in the thermal, mechanical, volumetric or other efficiency of any part alone, nor in the efficiency of the whole necessarily, but only in the earning power of the plant. It is essential, however, that this earning power be properly and not partially computed, and be measured not only over a month or a year, but for all time.

The manufacturer of machinery must be ever on guard to avoid being misled by false standards of value, and there are plenty of illustrations showing the fact that earning power and not thermal, mechanical, volumetric or any other standard of efficiency, must control and does control in the long run its construction, purchase, sale and operation, however much the latter may be useful as guides.

The most efficient heat engine on the market is the Diesel oil engine, which converts between 30 per cent. and 40 per cent. of the energy of the fuel into work at the shaft. Why, then, are not all steam, gas or other oil engines scrapped or driven from the market? The most efficient steam engines are of the multiple expansion, condensing type with superheated steam. Why do they then not displace all others? The most efficient blower is of the piston type. Why, then, are rotary blowers and fans still built and sold in such great quantities? Copper is, of the baser metals, by far the best conductor of heat, and very much better than iron or steel. Why, then, are not all boilers, feed water heaters, condensers, expansion coils, brine coolers, refrigeration coils, steam heating radiators, economizers and other heat transfer apparatus made of copper?

The answer to these and all other similar questions is to be found in the fact that other and more important conditions of cost, adaptability to the service or to particular locations, ability to use available sources of supply, adaptability to skilled or unskilled labor, to continuous or intermittent operation, life of the apparatus, and many others, requiring a broader and more difficult judgment and involving a more complicated criterion than any single efficiency, enter into the solution.—Prof. Charles E. Luck in *Ice and Refrigeration.*

Sir David Gill in a recent address said that the atmosphere of Mars is so rare that the temperature must be much lower than our own, so much so that some people had imagined that the snow caps were made up of frozen carbonic acid. He had never himself seen the canals which certain astronomers had spoken of, but, granted all that, he failed to see the remotest proof of habitation by man. He did not deny the existence of some kind of animals very different from ourselves, but he saw no proof of the work of any human beings on the enormous scale which had been talked about.

APRIL MEETING OF THE MECHANICAL ENGINEERS

The next monthly meeting of The American Society of Mechanical Engineers will be held in the auditorium of the Engineering Societies Building, New York, on the evening of April 14. The general subject of the meeting is The Conservation of our Natural Resources, which is now receiving unusual attention, because of the invitation of the President of the United States to the governors of the several states, and to the presidents of the national engineering societies, to confer with him in Washington on this important problem. The meeting will be addressed by four speakers who will consider forest preservation in its relation to water power, economy in the utilization of fuels, and the attitude of the engineer in regard to these. Dr. Henry S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching, will be one of the speakers and will discuss the "Relation of the Engineer to the Body Politic."

NOTES

A bill providing for the creation of a Bureau of Mines will be reported to the House of Represenatives at Washington at an early date. The only question undecided by the committee having the bill in charge is whether the bureau shall be under the jurisdiction of the Secretary of Commerce and Labor or the Secretary of the Interior.

Three aeroplanes will be contracted for by the Signal Corps of the United States army. The successful bidders, with their prices and time of delivery, are: Wright Brothers, Dayton, Ohio, $25,000, delivery in 200 days; A. M. Herring, New York City, $20,000, 180 days; J. F. Scott, Chicago, Ill, $1,000, 185 days. Of 41 bids which were received these three were the only ones that followed the Signal Corps specifications. The surprise bid was that of Mr. Scott, who, through patriotism, agreed to build a satisfactory machine that will fly for the mere cost of material.

The following method of thawing dynamite is recommended: Prepare a strong wooden box of the size required and line it with cloth. Have a tight fitting lid and place in the center of the box a can, which is also covered tightly. Then place hot water in the can and cover that. Place the powder in the box and heat from the can of hot water will thaw the dynamite gradually and thoroughly, and then it can be kept for hours in a convenient place ready for use. The tight cover will retain the heat in the box for a long time and all danger will be removed.

In Denmark they have time and seem to think it pays to seriously experiment with windmills for the development of electric power. Four wings are said to give the best results. With a sail area of 48 square meters (57.4 square yards) and a wind velocity of 6 meters per second (13.4 miles per hour) 8 horse power is obtained. With a "No. 3" wind (17.88 miles per hour) which is not unusual, the horse power is doubled.

Professor G. Frederick Wright says that at the beginning of the Christian era the edge of the Horseshoe cataract at Niagara was 1¾ miles lower down than now and at the time of the Trojan War it was at the head of the whirlpool rapids, nearly three miles below. At the period of human history marked by recent discoveries in Egypt and Babylonia this marvellous cataract was just beginning its work of erosion, while Canada was as well within the grasp of the glacial epoch as Greenland is to-day.

M. Charles Féry has constructed a very simple calorimeter for determining the calorific power of gases and liquids. The combustion is effected at the base of a glass chimney, the top of which supports a nickel plate pierced with a number of holes. The air necessary for combustion passes down a similar chimney, which is connected at its base with the former. The two junctions of a constantan-copper thermo-circuit are placed at the tops of the chimneys, and the electromotive force in the circuit is exactly proportional to the calorific power of the combustible and to the volume of it consumed in unit time.

Electrical air filtration is suggested by an English experimenter, who has discovered that a body positively electrified to 100 volts or over will, if placed in a sooty atmosphere, become covered with soot in a day, while a negatively charged body remains comparatively clean. In an application of this discovery to the fan intake of a ventilating system, a sheet of wire gauze was inserted in the intake flue, and electrified by connection to the positive of a 250-volt supply main. The gauze is reported to have extracted large quantities of soot from the air.

Mercury spilled on a table or floor is somewhat hard to collect, unless special precautions are taken, owing to its tendency to divide into small globules, which roll away at the slightest touch. If a wet ring is made round the spilled mercury by the aid of a wash bottle or other similar means, it will be found that the globules of mercury cannot readily cross this ring; the mercury can then be collected in a small shovel made from a piece of thin card, or even an ordinary envelope.

The question of how deep mining operations may be carried is much discussed, but has never been determined, except locally. In some instances it has been determined by economic conditions; in others by physical conditions, such as large floods of hot water, or high temperature of the air. From a mechanical standpoint equipment can be provided which will enable the sinking of shafts and the operation of mines to a depth approximating 10,000 feet. At present, about 5,000 feet is the limit. It is probable that the only inducement required to carry mining operations to a depth of two miles is rock sufficiently rich to pay the cost.

Wind pressure varies with the square of the velocity of the wind, but there is as yet no agreement as to the constant in the formula. According to Smeaton, $P=0.005V^2$; according to Martin $P = 0.004V^2$; according to Whipple and Dines, $P = 0.0029V^2$; where P is the pressure, when the surface is at right angles to the direction of the wind, in lb. per sq. ft. and V is the velocity in miles per hour. At 60 miles per hour these formulæ give the pressure in lb. per sq. ft. as 18, 14.4, and 10.44, respectively. The Smeaton formula is generally accepted as correct for small surfaces such as used in wind-mill practice, but it gives too large results for large solid bodies. The Smeaton formula is used by the U. S. Signal Service.

There is an immense traffic in wine on the Italian railroads; but the consignees this year complain bitterly of the "evaporation" from the casks en route. In a single fortnight a Milan firm found one cask with a gimlet hole and 25 gallons short; another with bung out and also 25 gallons short; three broken open with 60 gallons missing, and another which lacked the bung and 20 gallons of wine. These calamities are doubtless due to the failure of the railroads to keep a supply of water on their freight trains. From time immemorial it has been the custom of wagoners hauling wine into Rome (and doubtless other places) over the Campagna in the heat of the day to take their siesta under the shade of the cask, provided with a gimlet. But they always delivered the casks full, which was easy to do because further on the evaporation could be made good from the aqueducts.

At the recent meeting of the American Society of Heating and Ventilating Engineers, Mr. H. W. Whitten gave an account of tests made to determine the air leakage of ordinary windows. He found that with a wind pressure equal to 0.1 in. of water outside a window and a 1-32-in. clearance between window frame and sash, 105 cu. ft. of air were driven per hour through each lineal foot of such clearance space, while with a 1-16-in. clearance, the leakage was 184.8 cu. ft. per hour. With other windows, equipped with good metal weather strips and subjected to the same pressure, the leakage amounted to no more than 12 cu. ft. per lineal foot per hour. In tests made with a pressure of ½ in. of water, which corresponds to a wind velocity of 24 miles per hour, leakages were noted of 179 cu. ft. per lineal foot for 1-32-in. clearance, 402 cu. ft. for 1-16-in. clearance, and 45.6 cu. ft. for the sash with the metal weather strips. With a pressure double that used in the latter case, equivalent to a wind velocity of 48 miles per hour, the leakages were 432 cu. ft., 591.6 cu. ft. and 69 cu. ft.

Dr. Gans, of Garmisch, near Munich, chairman of the airship section of the Bavarian Automobile Club, has offered a prize of 10,000 marks, ($2,380) to be awarded to a flying machine, between May 1, and October 1, 1908, during the Munich Exhibition. Competitors of any nationality are eligible for this prize. The prize will be awarded to the aeronaut who, starting from the ground, succeeds in flying or remaining suspended in the air above the space assigned to him for the purpose, for 10 min., and in landing within that area after the 10 min. have elapsed. Balloons or flying machines fitted with balloons are not eligible for competition. Intending competitors must enroll their names on the list in the office of the Sports Committee of the Exhibition, "Munich, 1908," and send a description of their flying machine, accompanied by a photograph or sketch and pay an entrance fee. Further details may be had by applying to the office of the Sports Committee of the Exhibition, "Munich, 1908," 10 Neuhauserstrasse, Munich, Germany.

Reporting from Hanover, Consul Robert J. Thompson says that a newly invented refrigerating apparatus, a model of which has recently been privately exhibited in that German city, promises good results. The device is an extremely simple and inexpensive affair, costing perhaps not more than $1 to manufacture. It consists of a double-wall tin vessel with a capacity of 5 gallons or more. There is a hollow space between the two walls, or inner and outer vessels. This space completely surrounds the inner compartment and is about an inch in width. By the graduated admission of carbonic acid to this surrounding chamber at the bottom of the vessel, and from this surrounding chamber into the vessel proper at the top through a cross-armed tube, the contents of the vessel are frozen quickly and completely. Water is changed into ice in the space of sixty seconds. Meats, fruits, bottled beverages, may be chilled or frozen in a few seconds. But then you must have your supply of carbonic acid, so that it's not so cheap and handy after all as would seem to be implied above.

One of the first attempts at accurate measurement for furnace temperatures was by means of Seger cones. These are slender cones several inches in height, molded from some refractory material, such as clay, mixed with other substances in such proportions that cones having different melting points are obtained. A measurement of the high temperature is made by placing a number of the cones, having graduate melting points, in the furnace or kiln. Some of the cones may melt down while others are unaffected. The one which shows incipient fusion will register very close to the temperature of the furnace. Pyrometers of various types are much used in high-temperature measurements, the thermo-electric pyrometer being, perhaps, the most popular in the United States. This instrument is based upon the principle of the thermo-electric couple. In it two dissimilar metallic conductors are joined and connected in electric circuit with a galvanometer. The couple is inserted into the furnace when an electric current is generated which produces a deflection of the galvanometer needle, the amount of which deflection depends on the temperature.

LATEST U. S. PATENTS

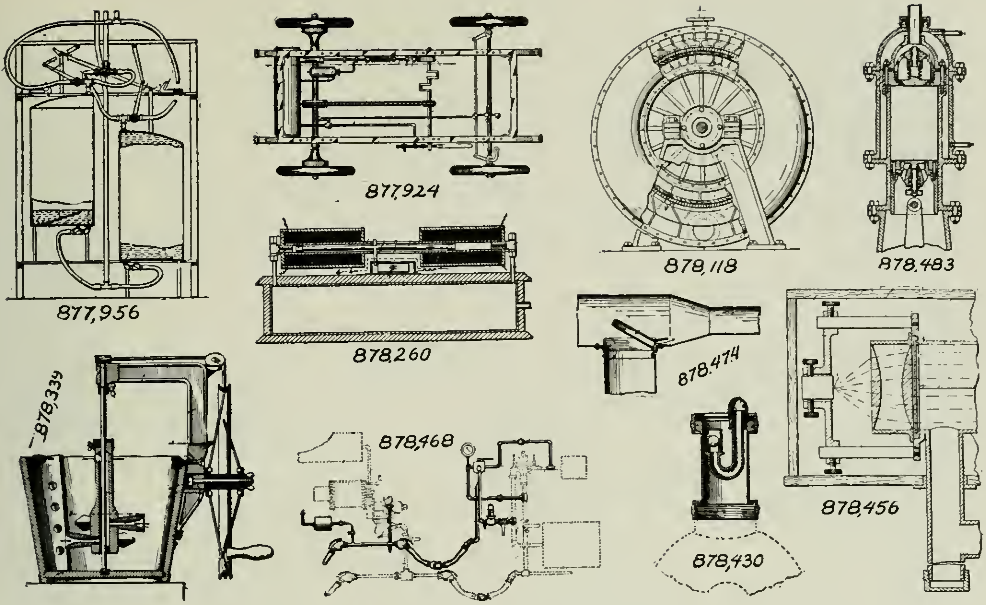
Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

FEBRUARY 4.

877,924. AIR - COMPRESSOR MECHANISM FOR SELF-PROPELLED VEHICLES. Ernest E. Hampton and Cicero G. Smith, Palisade, Colo.
877,956. WATER - ELEVATOR. Milo R. Shourds, North Powder, Oreg.
878,118. EXPANSIBLE - FLUID TURBINE. Benjamin S. Church, New York, N. Y.
878,260. ELECTRIC AIR-COMPRESSOR. Nelson M. Watson, Detroit, Mich.
878,339. AERATING - CHURN. Edwin H. Burnes, Amsterdam, N. Y.
878,430. ANTISIPHON-VALVE. William B. Thompson, Charleroi, Pa.
878,456. AUTOMATIC APPARATUS FOR DETECTING SMOKE AND THE LIKE. Horace Darwin, Cambridge, England.
878,468. AIR-BRAKE. William G. Pattee, Minneapolis, Minn.
878,474. VENTILATING DEVICE. James L. Waterbury and Clyde Waterman, Minneapolis, Minn.
878,483. ICE-MACHINE COMPRESSOR. Casper W. Miles, Cincinnati, Ohio.

FEBRUARY 11.

878,530. PNEUMATIC STACKER. Andrew J. Inglis, Chicago, Ill.
878,548. PNEUMATIC TOOL. Grosvenor D'W. Marcy, Dorchester, Mass.
878,560. AIR-GUN. David F. Polley, Plymouth, Mich.
878,562. VALVE MECHANISM FOR COMPRESSORS. Sidney A. Reeve, Worcester, Mass.
878,579. AIR-COMPRESSOR. Lamartine C. Trent, San Francisco, Cal.
878,601. AIR-BRAKE APPARATUS. Henry F. Bickel, Plainfield, N. J.
878,723. VACUUM APPARATUS. Stephen E. Griggs, Seattle, Wash.
878,805. PNEUMATIC RIVETER. Julius Keller, Philadelphia, Pa.
879,102. SAND-BLAST APPARATUS. John F. Hay, Erie, Pa.
879,106. PNEUMATIC HAMMER. Julius Keller, Philadelphia, Pa.
879,110. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. Christian Maerten, Jr., Martinsville, N. Y.



Pneumatic Patents February 4.

FEBRUARY 18.

879,213. AIR COMPRESSOR OR PUMP. William H. Tew, Glasgow, Scotland.

879,227. PNEUMATIC MOTOR. Charles G. Wieland, Hoboken, N. J.

879,267. CONTROLLING MEANS FOR PNEUMATICALLY-OPERATED DEVICES. Ray P. Jackson, Wilkinsburg, Pa.

879-273. AIR-PURIFYING APPARATUS. John H. Kinealy, Ferguson, Mo.

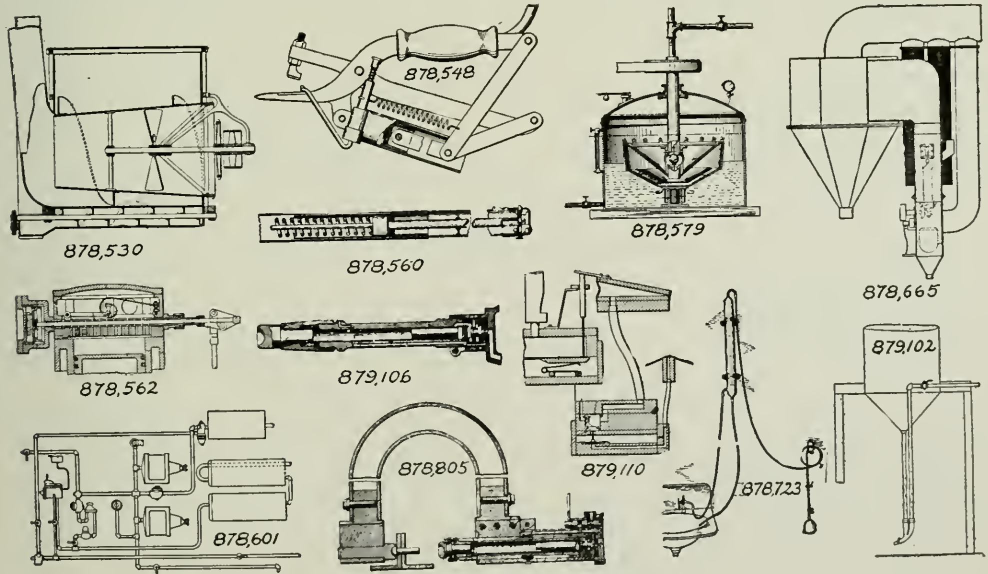
879,392. SYSTEM OF COOLING ROOMS BY COMPRESSED AIR. Olivier Levilly, Paris, France.

879,472. GAS-PRESSURE REGULATOR. Peter Keller, Chicago, Ill.

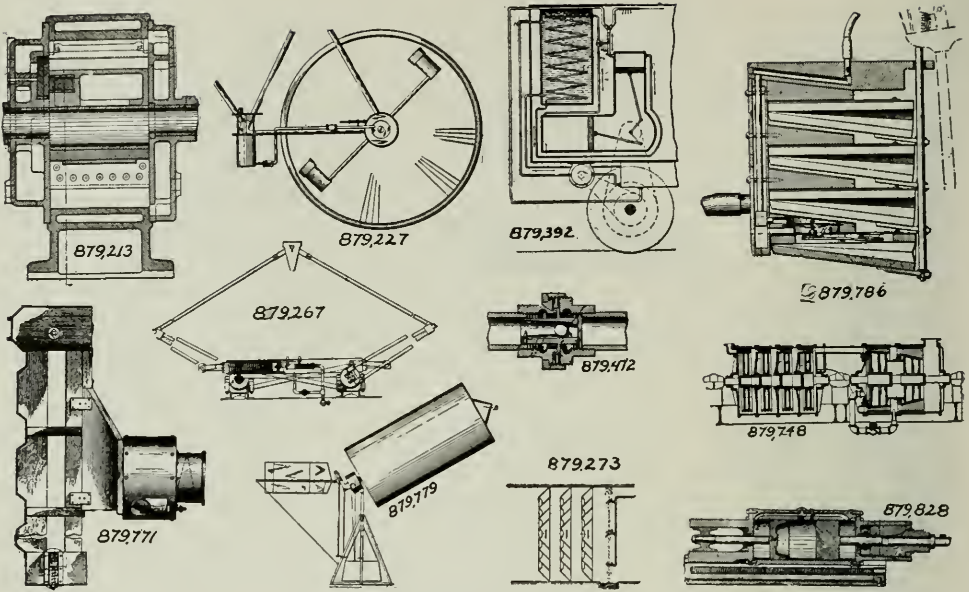
879,748. ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y.

879,771. PNEUMATIC GIN-FEEDER. Robert L. Hollingsworth, Decatur, Ga.

879,779. AIR-SHIP. Edgar F. Leeds, Mount Carmel, Ill.



Pneumatic Patents February 11.



Pneumatic Patents February 18.

879,786. PNEUMATIC ACTION. Hermann Meyer, New York, N. Y.

879,828. ELECTROPNEUMATIC DRILL. Olin S. Proctor, Denver, Colo.

FEBRUARY 25.

879,848. AEROPLANE. George H. Benedict, Chicago, Ill.

879,891. AIR-BRUSH. Jens A. Paasche, Chicago, Ill.

879,971. ROCK-DRILL. Bradford H. Locke, New York, N. Y.

880,110. ACETYLENE - GAS GENERATOR. Leon Sussman, Bayonne, N. J.

880-125. COMPOUND AIR - COMPRESSOR. Niels A. Christensen, Milwaukee, Wis.

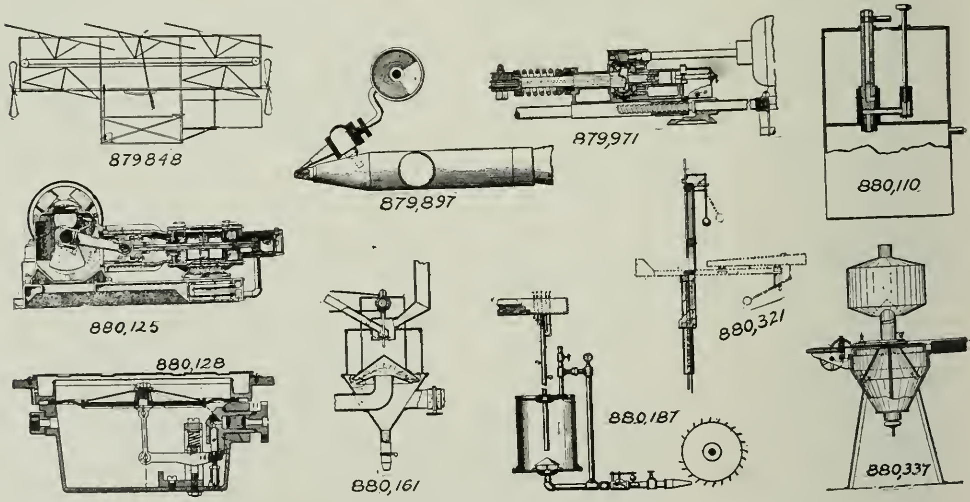
880,128. PRESSURE-REGULATOR. Robert M. Dixon, East Orange, N. J.

880,161. AIR AND DUST SEPARATOR. William S. Osborne, Marietta, Pa.

880,187. HYDRAULIC AIR - COMPRESSOR. Robert I. Blakney, Seattle, Wash.

880,321. WIND-MOTOR. Daniel D. McIntyre, Bucklin, Kans.

880,337. SAND-BLAST MACHINE. George S. Slocum, Newport, R. I.



Pneumatic Patents February 25.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC.

Vol. XIII MAY, 1908 No. 5

THE SOUTH AFRICAN MINES DRILLING CONTEST

The labor problem of the South African gold mines, or "on the Rand," has been for some time most serious and urgent. The deportation of 53,000 Chinamen left the colony with a labor supply deficient both in quantity and quality. A machine substitute for the former hand drill became an imperative necessity. A stope drill of some sort which, if operated in sufficient numbers could drill 100,000 3 foot holes per day, was urgently needed. These holes if drilled by hand would cost, roughly, $100,000, so that there was and is an immediate market for 2,000 to 5,000 stope drills when there is a practical assurance of their efficiency and reliability. Ten or twelve different makes of drills had been offered to the industry within a year, but still all was confusion as to their merits and in the ordinary course of events it would have taken probably years to decide which was best or near best.

In this contingency, to assist all concerned in arriving at a satisfactory conclusion in regard to the work of the drills offered, *South African Mines,* a most enterprising and worthy technical publication, proposed a formal contest, offering to the winning drill a trophy costing $500, the award to be made upon the aggregate depth of holes drilled in a given time, the only other condition being that the drill should be a one man drill. The competitors were to be at no expense other than the furnishing of their own drill and equipment, and a competent operator in each case.

The contest proposed was accepted and every preparation was made for a carefully conducted and absolutely fair trial. An advisory board of 16 men of the highest standing was selected and under their advice the preliminaries were outlined. The competition having assumed greater proportions than ever anticipated by the promoters, the entire mining industry having interests in one way or the other to be much affected by the result, the advisory committee was finally increased to 72. The Lord High Commissioner of the colony, Lord Selborne helped the affair untiringly, the character and extent of his interest being perhaps best shown by the half-tone herewith, in which he appears in the foreground actually operating the Gordon drill used in the underground contest.

Professor Orr was the judge of the surface contest and Professor Yates of the underground, both of whom presented elaborate reports with complete tabulated records of the entire contest. These reports it is, of course, entirely impossible to reproduce or even satisfactorily to abstract, but the results are very simply stated. The Gordon drill was so pronouncedly the leader all through and the triumphant winner at the end that there was not a word to be said. The record of the contest is unique in that there was not the slightest dispute, protest or misunderstanding throughout the entire proceedings.

A WELL DESERVED VICTORY.

Before the final reports of the judges were available *South African Mines* said:

"We are advised by both judges that the winner is the 'Gordon,' and that whatever positions may be assigned to the other competing drills, when results are compared in detail, no doubt exists regarding the pre-eminence of the victor. The winner is well deserved and popular; indeed, the highest tribute that has been paid to the searching character of the conditions under which the contest was carried out is the unanimous concensus of opinion that the best drill has won. The fine performance of the 'Gordon' was the feature of the contest. Not only did it beat all the others, and beat most of them by a substantial margin, but it fulfilled the claim of its owners and makers in a manner surprising to those of us who are familiar with the frequency with which the promise of a stope drill outruns performance. Underground the superiority of the Gordon was most marked. Alone of all the competitors it performed the full allotted task. Its lightness, portability, and water-feed attachment gave it an immense advantage.

"The more the conditions assimilated to actual mining practice, the more the Gordon drew ahead. On the surface, in the four granite blocks, it was merely the drill that did the most work in the stipulated time; amid the difficulties underground it was the drill, *and the only one,* that drilled all the time."

CONDITIONS OF THE SURFACE CONTEST.

Four granite blocks approximately 5 by 3 by 3 feet were conveniently placed, three of them with the front face inclined 25 degrees back from the vertical. Each drill was required to drill one hole in each block. The holes drilled in blocks A, B and C were to be wet holes drilled at right angles to the face. Dry holes were to be drilled in block D, the first and third to be horizontal and on the right side of the column; the second hole on the left hand side to be drilled at an angle of 10 degrees above the horizontal. These holes are always referred to by the drillers as dry holes, that is, holes into which water cannot be poured, but it was within the province of any competitor to supply water if his machine was specially designed to do so. No independent spray apparatus was admitted.

The trials began promptly each morning at 8:30. Each contestant was to do one hour's drilling in each of the three blocks, A, B and C, and one hour's dry drilling in block D. A pause of one quarter of an hour took place between leaving one block and column and starting on the next. During the three intermissions nothing could be done by the contestants to their machines other than to take them off one column and place them alongside the next column. There were two series of tests like this for each contestant, the first day's trials being at an air pressure of 50 lbs., and the second day's trials with the air at 60 lbs.

Suitable columns, rigidly erected, were furnished, with a column arm on each, column clamps being furnished by each contestant. The contestant might locate the column in a suitable position for drilling before the trial began, but could not adjust the arm or clamp. The drill itself was to lie three feet away from the column. At least one hole was to be drilled on each side of the column during each run on each block, each hole not less than 36 in. deep nor more than 45 in., and for each hole a change in the position of both the arm and the column clamp. A 50 ft. length of ¾ in. air hose was used, the machine end of the hose being disconnected before beginning work on each of the blocks. Each operator had a roped in space in front of the block 8 by 8 feet, only two contestants working each day.

CONDITIONS OF THE UNDERGROUND CONTEST.

The underground trials were held in a stope which dips about 25 degrees and is about 7 ft. wide. The underhand bench used for down holes was about 30 ft. long, and furnished a working face 4 ft. 6 in. to 5 ft. wide, all in banket. The bench for the test on dry holes was about 30 ft. further east. The face at that point was about 4 ft. 6 in. wide, about 18 in. of which was sandstone, the rest banket. This face was also about 30 ft. long, in which distance it rose about 9 ft. in height.

The more important conditions governing

the drilling of the holes were that eight dry holes should be drilled on one bench one day, and eight wet holes on the other bench the next day; each hole should require a change in position of both the arm and the column clamps; not more than two consecutive holes should be drilled on one side of the column, and not more than four holes from one set-up. After the holes were drilled, the machine, the bar and everything but the drill steel had to be returned to the place in the drift whence they had been taken when the test started. All holes had to be drilled following as near as possible the angle of dip of the banket, no holes to be less than 36 in. nor more than 45 in. long. Each competitor was allowed one spare machine.

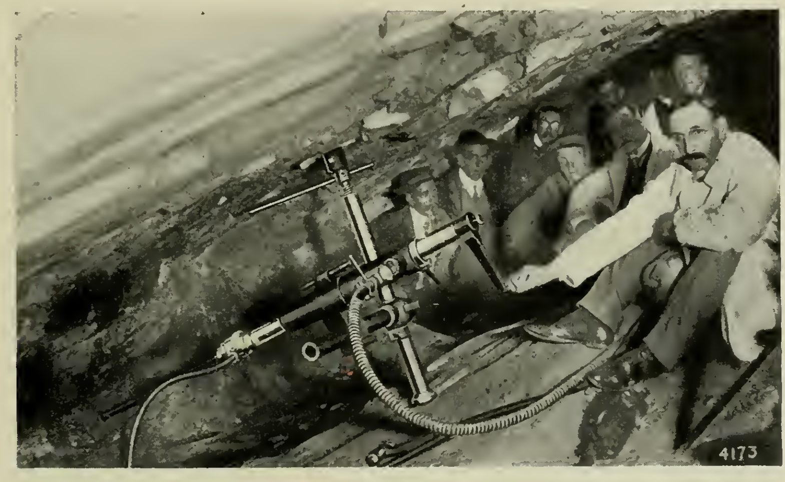
RESULTS.

The following is condensed from the summary of results prepared by *South African Mines*:

Nine drills competed, five with reciprocating pistons and four of the hammer type, the weights ranging from 44¼ to 129 lbs. The winning drill weighed 72 5-8 lbs; other drills are given in Table 1.

AS TO ONE MAN MACHINES.

The conditions were framed throughout for a one man drill competition, but not all the drills competing could be considered as belonging to the class. Several of them have usually had an unskilled colored laborer to rig up and take down the drill and column, and a white man either to supervise the running or to operate it himself. On the Rand economy of labor is of superlative importance and the



"GORDON" DRILL IN THE SOUTH AFRICAN DRILL CONTEST BEING OPERATED BY LORD SELBOURNE, GOVERNMENT HIGH COMMISSIONER.

No allowance was made for lost time except in case the air pressure fell below the specified pressure of 60 lbs. Two bars were furnished, one 2 ft. 6 in. closed, and the other 3 ft closed, and sufficient wedges and blocks were supplied for making a set-up quickly. Star and chisel bits had to be used for all eight holes; 60 drills were allowed. The bit of the 36 in. steel could not measure less than 1¼ in. The steel for deeper holes had to have a bit at least 1⅛ in. The test was determined by the number of inches drilled in the length of time expired between the taking of the drill from and the return of it to the drift. Water was furnished to the machines in whatever manner desired.

Name of machine.	Type.	Diameter of of cylinder. ins.	Length of stroke. ins.	Length of feed. ins.	Weight. lbs.
Kimber ...	Hammer ...	3⅛	3	12	100
Little Wonder .	Reciprocating piston	2	6	10	118¼
Gordon ...	Hammer ...	1 3/16	10	10	72⅝
Little Kid ...	Reciprocating piston	2	5	18	102¼
Baby Ingersoll	Do.	2¼	5	15	129¼
Flottmann ...	Hammer ...	2⅝	1¾	24	52¼
Hardsocg	Do ...	1 8	1⅛	18	44¼
Little Holman	Reciprocating piston	2	5	16	97½
Chersen ...	Do.	2¾	6	18	113⅜

TABLE 1, DETAILS OF COMPETING DRILLS.

strictly one man drill represents a great annual saving in operation when compared with the drill which requires two or three operators or assistants. Other things being nearly equal speed of drilling is of the first importance. However low the air consumption, or however little the cost of up-keep these things cannot count unless holes of good depth are drilled in reasonable time. The winning drill was the only machine which completed the task set. At the surface all the competitors with the exception of the Hardsocg ran for four hours both with 50 and 60 lbs. air pressure, although one or two machines were constantly in difficulty.

Name of Drill.	50 lbs pressure. Depth drilled.			60 lbs pressure. Depth drilled.		
	Depth drilled.	Time taken.	Inches per minute.	Depth drilled.	Time taken.	Inches per minute.
	Inches		Inches			
Kimber ...	155⅜	4 hrs	0·64	203	4 hrs	0·8
Little Wonder (tappet) ...	199⅞	4 hrs	0·83	239⅜	4 hrs	1·0
Gordon ...	340⅝	4 hrs	1·42	441¼	4 hrs	1·84
Little Kid ...	189⅝	4 hrs	0·79	270⅛	4 hrs	1·12
Hardsocg ...	11⅞	95 min	0·12	—	—	—
Baby Ingersoll	302	4 hrs	1·26	353	4 hrs	1·47
Flottmann ...	226⅜	4 hrs	0·94	302⅝	4 hrs	1·26
Little Holman	170⅝	4 hrs	0·71	202¼	4 hrs	0·84
Chersen ...	315	4 hrs	1·31	396¼	4 hrs	1·65

TABLE 2, RESULTS OF SURFACE CONTEST.

Name of Drill.	Wet Holes			Dry Holes.		
	Depth drilled.	Time taken.	Inches per minute.	Depth drilled.	Time taken.	Inches per minute.
	Inches			Inches		
Little Wonder (tappet) ...	211¼	3' 7 5 min	0·68	—	—	—
Gordon ...	306½	168 „	1·82	312	179 min	1·74
Little Kid ...	277	338¼ „	0·82	36	289 „	0·12
Baby Ingersoll	293½	253 „	1·16	192⅜	360½ „	0·53
Flottmann ...	77¼	137 „	0·56	—	—	—
Little Holman	352	291 „	1·21	78¼	245 „	0·32
Chorsen ..	319⅞	223 „	1·43	77⅝	288 „	0·27

TABLE 3, RESULTS OF UNDERGROUND CONTEST.

Underground the real practical value of the stope drills was determined. The conditions were: The drilling of eight holes in a wet or underhand stope, and eight in a dry or overhead stope, each hole to be not less than 36 in. deep. The Gordon drilled the 16 holes in 5 hours 47 min. The Chersen drilled 12 holes in 8 hours 29½ minutes, and the Baby Ingersoll did 13 holes in 10 hours 13½ min.

Tables 2 and 3 summarize the results, the former at the surface and the latter underground.

A number of interesting things are to be gathered from table 4, in which the total time is compared with the actual drilling time, the difference indicating the proportion of the time employed in setting up and making the required changes. This table besides establishing the relative handiness of the different drills also throws a most interesting light on the question of air pressures. This was a lesson especially needed in all the South African mines, where the prevailing pressures have been, as compared with practice elsewhere, absurdly low. The importance of the matter is shown by the contrast between the inches drilled per minute of actual running time with 50 lbs. air pressure and the number drilled at 60 lbs.

Name of Machine.	50 lbs pressure			60 lbs pressure.		
	Inches drilled per min. of total time.	Inches drilled per min. of actual running time.	Percent'ge actual running time is of total time.	Inches drilled per min. of total time.	Inches drilled per min. of actual running time.	Percent'ge actual running time is of total time.
Kimber ...	0·64	1·06	60·7	0·8	1·6	50
Little Wonder...	0·83	1·17	70·9	1·0	1·45	68
Gordon ...	1·42	1·65	86	1·84	2·14	86
Little Kid ...	0·79	1·08	72·5	1·12	1·47	76·6
Baby Ingersoll .	1·26	1·64	76·7	1·47	2·06	71·3
Flottmann ...	0·94	1·55	60·9	1·26	1·69	72·0
Little Holman .	0·71	0·88	80·3	0·84	1·07	78·4
Chersen ...	1·31	1·74	75·3	1·65	2·14	77·1

TABLE 4, TOTAL TIME AND ACTUAL DRILLING TIME.

The higher efficiency of the then leading drills at the higher pressure was as follows:

Gordon........................30 per cent.
Chersen........................23 per cent.
Baby Ingersoll...............25½ per cent...

These calculations are, of course, all based on completed holes only, no hole less than 36 inches nor any portion of a hole over 45 inches being counted.

Name of Drill.	At Surface.		Underground.		Av. inches per min. over full four days' run.
	Inches drilled.	Time drilling—min.	Inches drilled.	Time drilling—min.	
1. Gordon ...	781·875	480	618·5	347	1·69
2. Chersen ..	711·25	480	397·25	509·5	1·12
3. Baby Ingersoll .	655	480	485·75	613·5	1·04
4. Flottmann ...	529	480	77·25	137	0·98
5. Little Wonder...	439·25	480	211·25	307·5	0·83
6. Little Holman...	372·875	480	430·25	536	0·79
7. Little Kid ...	459·5	480	313	627·25	0·69
8. Kimber ...	358·375	480	—	199	0·52

TABLE 5, AVERAGE OF TOTAL WORK.

DRILL STEELS.

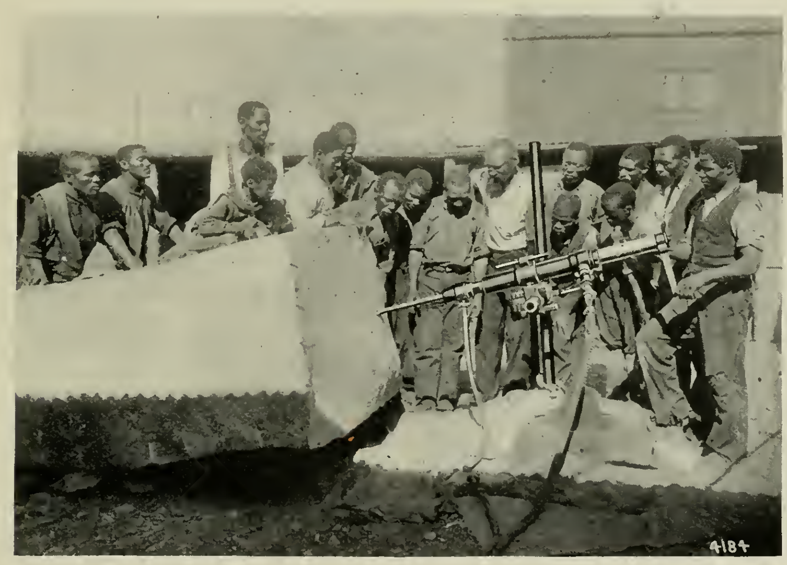
Of the nine drills competing five had considerable trouble with their drill steels, one or two machines retiring from the contest on this account. The failure of certain machines underground was, however, really on account of their inability to drill dry holes.

PREVENTING MINER'S PHTHISIS.

Another point of interest in the contest not only to the medical man, but to all connected with the mining industry was in its bearing upon the problem of arresting the evil of miner's phthisis. The Gordon drill method of wetting the holes by feeding water through hollow steel was a novel and striking feature. It was thought that it should do more in ridding the Rand of this pestilential disease, than all the commissions that have sat and all the respirators and atomizers ever invented.

AS TO THE OPERATORS.

Of course there was a difference in the operators of the different drills. Mr. Frank Crean, who ran the Gordon proved himself a most efficient workman and it is only fair to him to say that had the Gordon been in less skilled hands it would not have done as good work. On the other hand, says *South African Mines,* we should be doing the drill—which is essentially a "fool proof" machine requiring from the runner extremely little practice to be able to operate it successfully—a great injustice if we attributed the success of the drill to the dexterity of its operator. A native operator shortly before this trial ran the machine in regular mining work and obtained results which conclusively proved that the Gordon is not a drill for skilled operators only, but can render most efficient service with any average Rand mine "boy."

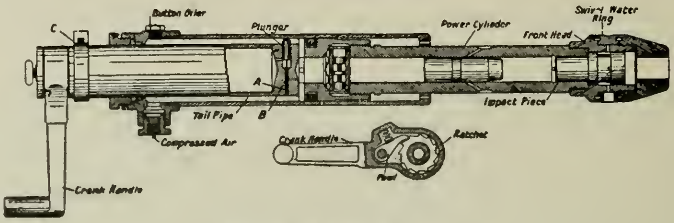


BOY MALAMBA DRILLING WITH GORDON DRILL AS MUCH AS ALL THE ONLOOKERS WORKING BY HAND

DESCRIPTION OF THE GORDON DRILL.

The construction and operation of this drill is easily understood by reference to the cut on the following page; and the most evident feature of it is its simplicity. This will appeal especially to the man of the shop familiar with the building of drills. It appears at once that there are no parts of such intricate shape as to call for castings. Every part can be and is made of forged steel of the precise quality best adapted to the specific function of that part. All parts are machined all over, and there is every opportunity for the most accurate fit and the finest finish of surfaces, all parts requiring it being hardened, and the fits being made by grinding to micrometric gauges.

The barrel or shell of the drill is round and is held in a round clamp, so that in setting it it can be turned and slid to the most satisfactory position before clamping, and then it can be clamped with absolute security. The tail pipe slides in the barrel with a cup leather packing at the rear. The space between the tail pipe and the barrel being filled with air at the working pressure, this pressure acts against the annular surface exposed to it at the head of the power cylinder, driving that constantly forward and pressing the steel bit against the rock. The drill therefore always feeds or drives the power cylinder forward when the pressure is on, and the runner has nothing to do with it and never has to think of it.



SECTION OF GORDON DRILL

The tail pipe is fastened to the rear end of the power cylinder so that they turn or move longitudinally together. The power cylinder has a front head and to this in turn is secured a nose or end piece with a square or hexagonal hole into which the end of the steel bit is inserted. The rear end of the tail piece has a ratchet and a crank which is turned usually slowly but quite constantly while the drill is in operation, this turning the power cylinder and the bit in the rock. The use of the ratchet compels the runner if he turns the crank at all to turn the cylinder and bit all the way round and not merely move it back and forth. The tail pipe serves as an oil reservoir and the oil may be poured in at the centre of the crank end. A little plunger is shown which slides in a side hole in the solid forward end of the tail pipe. There is a small tail or stem *B* on the inner end of this plunger, and a spring *A* forces the stem and plunger outward so that normally the plunger touches the inside of the shell as shown. When the machine is in operation the oil in the tail pipe passes through the small hole and fills the space below the plunger. When the tail pipe and cylinder are drawn back to insert a fresh bit the plunger is forced inwards when it strikes the beveled shoulder and enters the part of the shell which fits the tail pipe. This forces the small amount of oil in the space below the plunger out through a second small port into the space immediately behind the valve, from which it is carried along by the air to lubricate the valve and piston.

When drilling "up" holes the oil will not flow into the space below the plunger and in such cases the oil must be inserted at intervals through the bottom oiler, from which point it is carried along by the air and keeps every working part oiled.

The forward end of the casing is made a loose sliding fit on the power cylinder while forwardly directed ports permit the escape of exhaust air from the forward end of the casing in a direction which prevents mud thrown out of the hole which is being drilled from flying into the face of the operator.

The adjustable collar *C* may be tightened on the tail pipe at any point, thus forming a stop, after which the tail pipe can only advance until the collar comes in contact with the gland just in front of it. This is chiefly used to keep the machine back when changing bits, while drilling steep down holes or when transporting the machine to prevent sliding. When the tail pipe is drawn clear back the machine is, of course, no longer over all than in any other position.

On the forward end of the machine is mounted a swivel water ring, to which is attached a hose leading from a water supply with a slight pressure. Leather packing rings prevent the escape of water from the sides of this swivel ring. The water entering the swivel ring from the attached hose passes through holes in the front head and impact piece and thence through a central hole extending the entire length of the drill steel to the bottom of the hole in the rock. The impact piece receives the blows of the piston and transmits the force to the drill steel. This impact piece also serves to keep grit out of the cylinder when the machine is not in use, and as a means of introducing water from the swivel to the central hole in the drill steel.

It is not necessary to describe in detail the valve motion. The drill belongs to the family of "pneumatic tools," the work being done by the rapid blows of the piston upon the impact piece. The piston always starts when the pressure is turned on and it continues working as long as the pressure is maintained.

CLAIMS MADE FOR THE DRILL.

Besides the actual results in work done under all the various conditions specified, the drill in itself completely satisfies the requirements. It is in every sense a one man drill. It is light, so that one man can easily move it and place it in every position required. It is simple in construction and operation so that an unskilled runner can do with it almost as much work as the most skilled, the actual speed of drilling being entirely independent of outside manipulation. Setting the machine and changing the steels is all that calls for any skill. It drills equally fast on up, down or flat holes. It may be operated in any stope which is wide enough to permit the operator to get around in. It has strength and durability due to the fact that all the wearing surfaces are of hardened steel. It is kept automatically oiled. Water is at all times delivered to the bottom of the hole, keeping the hole clear and the bits free. Most important of all, the water kills the dust, and association with this drill cannot produce Miner's phthisis. In the open air trials not a particle of dust was to be seen.

The trial of course decided only the one thing. The Gorden drill, as a one man drill, did much more work in aggregate depth of holes drilled then any other, did it on the surface and underground, in wet holes and in dry holes and at both of the working pressures employed. As to the wear of the drill there is strong presumption of its easy maintenance, of the air consumption there is no evidence and of the range of work to which the drill may be adapted there may be different opinions, but where it was tried and as it was tried it was a great success.

BREATHING HIGH MOUNTAIN AIR

Experiements which have been conducted in the Andes to determine the effects of the atmosphere at high altitudes upon the functions of the body have shown that at heights approximating three miles the air pressure is so light as to produce incapacity for work, prostration and sometimes death. The absolute air pressure being only about 60 per cent. of that at sea level, while the lungs may take in the normal volume of air for inhalation the actual weight of the inspired air, and therefore of the oxygen constituent of it, is proportionately reduced and, to make up for the deficiency, both the respiration and the heart action are automatically accelerated, while even at that the life functions are not fully sustained.

Professor Todd, the astronomer, of Amherst College, who is conducting experiments in South America, ascended a mountain in the Andes to an altitude of 14,000 feet, there experiencing the usual change of respiration and its accompaniments due to the diminished air pressure. While in this condition he entered an air receiver where the pressure was gradually increased to that corresponding to an altitude of 1,000 feet when his pulse was reduced from 104 to 91 and his breathing and general physical condition became entirely normal. A decompression of the air in the receiver to that surrounding it was made in seventeen minutes so that no serious consequences resulted from the experiment. The experiment is looked upon as important as bearing upon the treatment of diseases produced by protracted subjection to abnormal air pressures.

The Pittsburg Coal Company has practically decided to discontinue the use of black powder in the fifty-four mines of the company. Dynamite, or an explosive similar to it, will be substituted. It is claimed that black powder makes a longer and hotter flame than dynamite, and in "blow-out" shots is more likely to ignite pocket gas.

AUTOGENOUS WELDING

This process consists of heating the metal by a blow pipe using oxygen and acetylene gas. With this the metal is heated to the melting point and a steel rod is passed along with the flames, steel melting off from the rod and flowing, into the point until it has been filled.

The flame is largely carbon monoxide but at the tip where the heating takes place it is converted into carbon dioxide. This gives a flame that will neither carbonize nor oxidize the metal. In lighting the blow-pipe, the acetylene is first turned on full, then the oxygen is added until the flame has only a single cone whose apex has a temperature of 6300 degrees Fahrenheit. Too much acetylene produces two cones and a white color, while an excess of oxygen is shown by the flame assuming a violet tint. The best welding results are obtainable with 1.7 volumes of oxygen to one of acetylene.

The oxygen for the process is obtained by using a special generator which has two lead-lined chambers with a scrubber and settling chamber between them.

In one chamebr is put a chemical charge of calcium compound and copper sulphate and the chamber filled with lukewarm water, after which the solution is stirred.

In the second chamber a solution of iron sulphate and water is poured. These two solutions produce a large quantity of oxygen which is passed through the scrubber into a receiving tank. The oxygen is drawn from this tank by an air compressor which compresses it to 147 pounds in a storage tank, from which it is taken through copper pipes to the point required.

The acetylene gas is manufactured in the ordinary way from calcium carbide, and used at a pressure of 2 or 3 pounds.

THE WELDING OPERATION.

Through a system of piping, the flame is easily carried to the work, which saves the labor of moving large pieces of work to a forge or hammer for welding. Pieces one inch thick have been successfully welded with this process, but its best application is in welding sheet metal, as joints of great length can be easily welded. In fact its only limit is the length of the joint and the time needed, and this latter can be carried out indefinitely.

Oxy-acetylene welding gives its best results in the welding of steel, but cast iron is being welded successfully as well as copper, brass and bronze. The different metals can also be welded together as is shown in Fig. 1 in which four plates were butted together and welded.

One plate was steel, as shown by the white square; another brass, as shown by the darker square in the diagonally opposite corner; and the two very dark squares were copper and bronze respectively. After welding these they were bent and broken at the joints to see if they were thoroughly welded, and from the appearance of the fractures they would indicate a perfect weld. The steel welded to the copper and bronze as well as the brass did. Owing to the high heat of the flame, however, the lead and zinc in the brass and bronze melted out leaving holes in the metal.

Welds of 90 per cent. efficiency can be made with careful workmanship and the cost in wages and gas for welding plates ⅛ of an inch thick is about 2 cents per foot.

A variation of this process has been made which cheapens the oxygen so that it can be made to cover a wider field of usefulness. This is the discovery of an oxygen powder which has been named "epurite." It is a substance containing oxygen in a latent state, and a form susceptible of easy liberation on contact with water. There is said to be no danger of explosion in connection with this process as there is no large quantity of gas stored in tanks under high pressure.

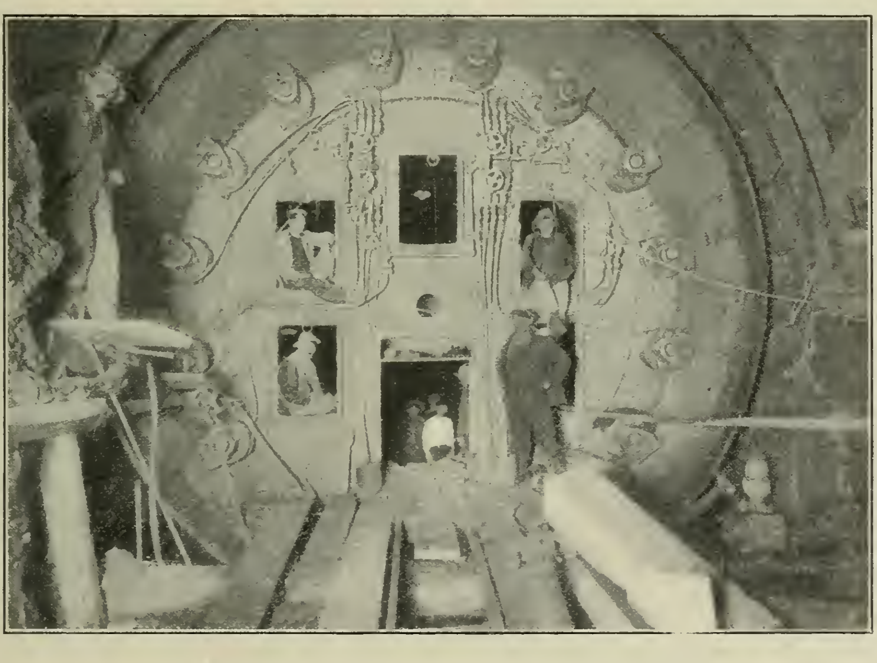
Oxygen and hydrogen are also being used in the proportion of from 2 to 4 parts hydrogen to 1 of oxygen, and the hottest part of this flame is about ⅜ of an inch from the point of the burner.

Two parts hydrogen to one of oxygen will give a flame with a temperature of about 4350 degrees Fahrenheit, but if a flame is desired with a reducing action it is necessary to use 4 parts of hydrogen to 1 of oxygen, and this will have a temperature of about 3450 degrees Fahrenheit. This flame will melt iron and cause it to weld even if the surfaces are not clean, as any rust present will be reduced.

This lower temperature of the flame is really better for sheets up to ⅛ of an inch thick, as the melting of the metal is less rapid and less explosive, giving a welded joint that is cleaner and with fewer scars and blisters.—*American Machinist.*

THE HUDSON-MANHATTAN TUNNELS

In our April issue we briefly alluded, editorially, to New York's Compressed Air Harvest, which the various subfluvian tunnels, fourteen in number, now completed or coming to completion so nearly together may properly be characterized. These may be considered a first crop, to be successively followed by others under the stimulus of the Metropolitan life forces; but in a periodical of the scope and dimensions of COMPRESSED AIR, it is quite impossible to speak even of this first crop as a whole. We, therefore, here have to do only with the Hudson-Manhattan, or, as they have come to be popularly known, the McAdoo tunnels.



INNER FACE OF SHIELD—HUDSON MANHATTAN TUNNELS.

The name McAdoo is synonymous with success in this case. A third of a century ago DeWitt Clinton Haskins started the enterprise and began the construction of a brick wall tunnel from both sides of the river. There was one very serious accident, and this with legal and financial difficulties paralyzed the undertaking. In 1902 the New York & New Jersey Railroad Company, under Mr. McAdoo began serious work. The next year this was merged with the Hudson & Manhattan Railroad Company, and later the "Hudson Companies" was formed to conduct the construction and real estate operations. Harvey Fisk & Sons have successfully financed the undertaking, and it is estimated that when the entire work is completed $70,000,000 will have been expended.

A little study of the accompanying map is necessary to a clear understanding of the ramifications and connections of this special system of tunnels, these alone being shown. The system as a whole may be considered in construction as consisting of four sections, only the first of which is as yet open to the public. This is the twin tube extending from Hoboken, N. J., near the D., L. & W. terminal, to Sixth avenue, New York. It enters Manhattan two blocks below Christopher street, and then passes up through the shipping district in Sixth avenue to Thirty-third street, near the front of the Pennsylvania Railroad station now under construction.

The south twin tunnels, which may be called the second section, have been driven entirely from the Jersey side of the river, and are now completed to within a few hundred feet of the New York side. At Jersey City a large terminal station has been hewn out of the solid rock, eighty-five feet below the present station of the Pennsylvania Railroad. The tunnel station here is 150 feet long, with approaches 1,000 feet long, and great elevators reaching the surface. These tunnels enter New York between Cortlandt and Fulton streets, the station being surmounted by two of the largest and most magnificent office buildings in the city. This station also will connect with the present Subway at Broadway, only one block to the east.

The third section is a land tunnel parallel with the Hudson, connecting the Hoboken terminal with that in Jersey City, and also commanding the passenger stations of four trunk railroad lines which are now entirely dependent upon ferry service.

The fourth section, also a land tunnel, runs from the Jersey City terminal under the Pennsylvania station toward Newark. This tunnel passes under the most crowded portion of Jersey City, coming to the surface at the outskirts and the tunnel trains will then use the Pennsylvania tracks to Newark.

It will be noted that more than one half of this entire system is land tunnel, or, in Sixth avenue, typical subway, involving generally, no unusual difficulties; but the river tunnel work was among the most serious engineering ever undertaken and carried to success. On both the subterranean and the subaqeous work, compressed air was, of course, the great reliance.

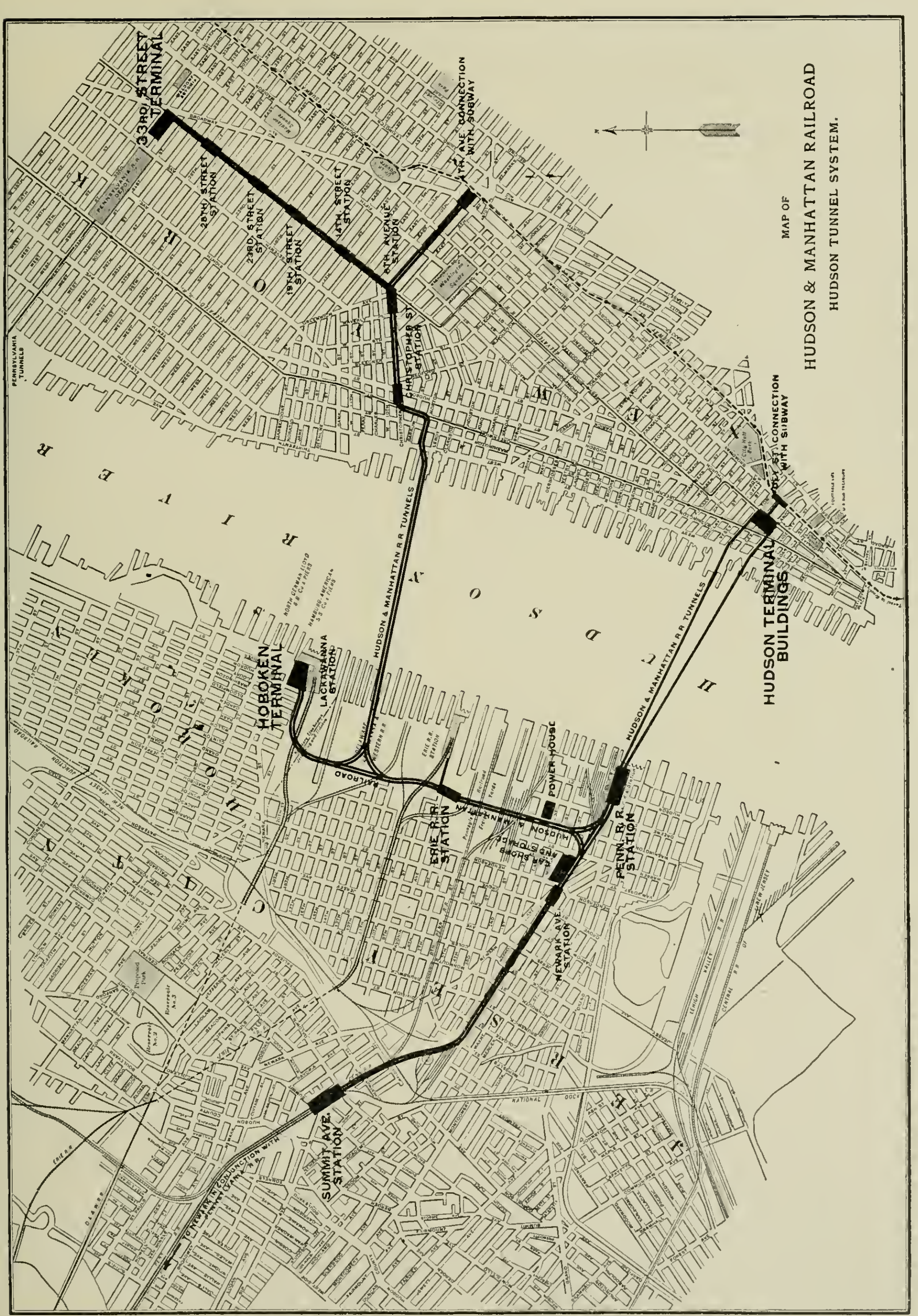
When the work was taken up anew by Mr. McAdoo, Mr. Charles M. Jacobs became chief engineer, assisted by Mr. J. Vipond Davis. The north tunnel had then been driven 3,800 feet from the New Jersey end. The shield which had been previously used in the work was continued, but with necessary changes, as it was then approaching a spur of rock which would make it necessary to drill and blast in advance of the shield. A heavy apron was added which extended 6 feet in advance of the shield, and under its protection the men were able to work and cut the rock. This work was done under an air pressure of 33 pounds, there being 14 feet of silt and 65 feet of water above. At times when blows occurred the river bed was blanketed with clay before operations could be continued.

In beginning the south tunnel, the other twin, changes were made in the tunnel design, and in the mode of procedure. The size was reduced to a diameter of 15 feet 3 inches in the clear. The cast plates bolted together insured the true circular section, and the shield could be manipulated to follow the exact alignment. An hydraulic erector was carried by the shield for placing the plates in position.

The shield was forced forward by 16 hydraulic rams with a total pressure of 2,500 tons. It was found that the shield could be thus forced forward, displacing the silt, without requiring any excavation. The cost of construction in consequence of this became much less than ever before attained in this class of work. By the original method 5 feet in 24 hours was considered excellent progress, while with the new method a record of 72 feet in 24 hours was made in one of the Cortlandt street tunnels.

Some interesting details of this undertaking are given in the words of Mr. Jacobs himself in the article which immediately follows this. In the North tunnels trains are now running regularly, carrying many passengers, with every indication that when the system is completed, and the anticipated connections are made with existing lines, it will be at once and continuously crowded to its full capacity, and the people will be clamoring for more.

The latest improvements have been incorporated in the new equipment. The cars are of steel, fire proof, have large sliding doors at the middle as well as at the ends, and the terminal station platforms are arranged for passengers to be entering and leaving the cars at the same time. The doors of the cars are operated by compressed air, and no signal bells are used. The automatic adjustment is such that not until the last door in the train is securely closed is it possible to give the electric flash signal to the motorman to start the train. There is a triple set of automatic devices for stopping the train. The ventilation of the tunnels takes care of itself in the most satisfactory manner. The trains in each tunnel run constantly in one direction, each train acts as a piston, forcing the air ahead of it with a fresh supply of air from the outside rushing in to take the place of the air expelled.



HUDSON COMPANIES' TUNNELS AND CONNECTIONS.

THE TERMINAL BUILDINGS.

The buildings which surmount the Cortlandt street terminal, extending from Cortlandt to Fulton streets, with Dey street between them, are in themselves another triumph of modern engineering. In business hours 10,000 persons will find constant occupation in them, and in the station below in the rush hours it will be possible to dispose of 1,000 passengers per minute. Before the superstructure could be begun an immense cofferdam inclosing the entire space of two city blocks, 420 by 192 feet, had to be sunk under air pressure to the depth of from seventy-five to ninety-eight feet below the surface, and the concrete foundations of all rest upon solid rock, none of the surrounding structures nor the traffic on the intervening and adjacent streets being stopped.

THE AIR COMPRESSORS.

It is interesting to note that the original Ingersoll air compressor installed at the Hoboken end of the first tunnel in 1880 was continued in service until the completion of the tunnels. This compressor was overhauled in 1890, and is rated as an Ingersoll, Class "A," with cylinders 20 and 20¼ by 30 inch stroke, free air capacity, 1,098 cu. ft. per minute, the other compressors comprising the plants of the three power houses responsible for the tunnel work of the Hudson Companies, all belong to the same family. Besides the compressor mentioned, the Hoboken plant included two Class "A" compressors, 22 and 26¼ by 24 inch stroke, free air capacity, 3,686 cu. ft. per minute, and one duplex Class "H" machine, 16 and 20¼ by 16 inch stroke, free air capacity, 2,178 cu. ft. per minute.

The Morton street plant at the Manhattan end of the same tunnels, comprised one duplex Road compressor, 22 and 22 by 24 inch stroke, free air capacity 2,640 cu. ft. per min., one Ingersoll Class "A" 22 and 22¼ by 24, free air capacity 1,320 cu. ft. per min., one 20 and 22¼ by 24, free air 1,320, and one 16 and 16¼ by 18, free air, 698.

At the Jersey City plant opposite Cortlandt street the compressors were three Ingersoll, Class H C, cross compound steam, two stage air compressors for high pressure air, and three Ingersoll, Class H, cross compound steam and duplex, single stage air for the low pressure air. The former were 14 and 28 inch steam and 24¼ and 14¼ air, by 16 inch stroke, free air capacity 4,710 cu. ft. per min., and the latter of the same steam cylinder dimensions with air cylinders 22¼ by 16 inch stroke, free air capacity 7,920 cu. ft. per min.

Supreme above all else in the complete ultimate success was of course the personnel. William G. McAdoo, a Tennessee lawyer, took up the project when it had twice failed and was by many regarded as a hopeless proposition. The discerning public permanently attaches his name as the familiar designation of what is now one of the City's permanent agencies of life and growth. Then there are others: Walter G. Oakman, president of the Hudson Companies; Pliny Fiske and William H. Barnum, financiers and bankers; Charles M. Jacobs, the alert, resourceful, experienced engineer, who is also consulting expert for the Pennsylvania tunnels; J. Vipond Davies, the partner and deputy of Mr. Jacobs, who has given more concentrated and continuous attention to the work in detail; L. B. Stillwell and Hugh Hazelton, electrical engineers; J. Van Vleck, mechanical engineer and Kenyon B. Conger whose responsibilities have had to do with the great terminal buildings.

The supreme continuous function of the system will be the conveyance of breadwinners of the Metropolis to and from their homes distributed over many miles and through the countless cities and towns of New Jersey, and it is not easy to say whether New York or New Jersey will be the most benefited. As to the enormous traffic secured it is only necessary to remember that perhaps three quarters of the passengers carried will be those who will each individually make over 600 trips per year.

TUNNEL ENGINEERING DIFFICULTIES AND EXPEDIENTS

The slight account in our April issue of the work of building the East River gas tunnel, fifteen years ago, bore testimony above everything else to the ready resourcefulness and constant push of Charles M. Jacobs, the engineer of that work. These characteristics are equally prominent in the following taken from a recent address by Mr. Jacobs, now chief engineer of the Hudson and Manhattan tunnels, before the Yale Club of New York.

IMPATIENCE MAKES WORK.

At the beginning of the work on the south tube of the uptown tunnel, the shield from the Hoboken side was being advanced through the silt with the shield doors closed so as to save the cost of excavation. While the heading was still under the Lackawanna coal dock the night superintendent, thinking that the shield was moving very slowly, determined, contrary to orders, to open one of the center doors so as to let the mud come in and so let the shield go ahead faster. The silt shot in under such pressure that it buried some of the men before they could escape; the rest of the shift got away through the upper emergency lock which was then 115 ft. from the shield face. The heading was lost and, the tunnel between the shield and the lock being filled solid with mud, there was no space for air pressure in which men could be put to work digging out the mud. The coal dock was crowded with shipping and, furthermore, the Lackawanna at that time was not particularly favorable to the tunnel enterprise, so it would have been almost impossible to get permission to dredge out the bed of the river in front of the shield so that a diver could go down and timber up the exterior opening to the doorway. The problem was solved as follows: Two heavy mainsails (one being an old one of the cup defender Reliance) were procured and a double canvas cover, about 60 ft. by 40 ft. made of them. Around the edges were secured small weights of pig iron. The canvas was spread on a flat barge and lines carried to fixed points to hold the mainsail in the position; the barge was withdrawn and the mainsail allowed to drop to the bed of the river, 30 ft. of it covering the shield and the remaining 30 ft. extending out beyond the face toward the middle of the river. One of the pipe valves in the lock was then opened and the mud, under the direct pressure of the river, shot into the tunnel westward of the lock for 40 ft. It came in a solid stream for eight days and nights. Finally it let up for a few minutes, began again and then stopped. A cavity had formed in the bed of the river outside the cutting edge of the shield until the canvas dropped with the cavity and was eventually drawn into the opening of the doorway through which the mud was pouring. A small cavity was excavated in the mudfilled tube ahead of the lock and the air pressure being put on, it immediately relieved much of the strain on the temporary canvas cover. Miners were then able to get into the tunnel and dig out the mud. In about nine days the heading was recovered and the door on the inside closed.

AN EMERGENCY ANTICIPATED.

The north tube is an extension of an old tunnel abandoned some years ago. Within 100 ft. from the point where the shield stopped in the previous attempt, was a reef of rock, standing from 1 to 16 ft. above the intended grade of the tunnel. Before the shield arrived at this point, it was necessary to build a temporary workshop in the river ahead of the shield, so as to build on the front of it a steel apron under which men could work in drilling the rock and blasting it out of the path of the shield. Above the rock was soft silt and, above that, from 60 to 65 ft. of water. It was expected that, in blasting the rock with so slight a cover and with such heavy water pressure, the heading would probably be blown out. Clay loaded on barges was, therefore, always held in readiness to be dumped into any such blowout. After a few weeks the expected blowout occured and the 900 ft. of tunnel from lock to heading was flooded. The men at work escaped. The clay scows were immediately brought over the blowout and dumped, thus blocking the hole. The water was pumped out into the western workings, and within 11 hours men were able to reach the heading on a small raft. No damage was found and work was soon under way again. In all, only 21 hours time were lost. There were two more blowouts while the tunnel was being built across the 700 ft. of reef, and in each case they were similarly dealt with.

MAKING BRICKS UNDER WATER.

Finally, however, there arose a problem which could not be dealt with by dropping these clay blankets. At the extreme eastern end of the reef the rock rises about 16 ft. above the bottom of the cutting edge of the shield. The tunnel at this point is so near the bottom of the river that the clay was almost fluid and continually slipped into the pockets of the shield, so that the men could not get out underneath the apron to drill the rock. Scow after scow was dumped, but the clay would not hold. Finally blow pipe flames, fed from two tanks of kerosene, were directed against the exposed clay until it was indurated, so as to hold its position while the men drilled the rock. The blow pipe process took eight hours, during which time streams of water were continually played on the shield structure to prevent its being damaged by the high temperature. This is probably the first time that man has made brick in the bed of a river.

REINFORCED CONCRETE CAISSONS.

There was a serious problem on the New Jersey side in regard to the transverse tunnel running from the river tubes north to the Lackawanna terminal and south to the Erie and Pennsylvania terminals, and thence to the downtown tunnel of the Hudson & Manhattan. The problem was to eliminate, as far as practicable, all crossings of the tubes at grade and still give each track a connection with all the terminals mentioned. The south tube of the uptown tunnel was, accordingly, carried under the north tube at the Fifteenth street shaft, Jersey City. About 200 ft. west of this shaft a reinforced concrete caisson (known as caisson No. 1) was sunk from the surface; the caisson is a two-story structure, carrying two tracks on each level. The south tube enters on the lower level, and trains are switched in the caisson to the north or to the south. The north tube comes on the upper level, and branches similarly north and south. The caisson is 105 ft. long, 23 ft. wide at the easterly end, and 46 ft. wide at the westerly end; it is 51 ft. high, is sunk 85 ft. below tide level, and the total weight is about 10,000 tons. There is a similar caisson (No. 2) about 700 ft. west of the first one. In caisson No. 2 trains from Hoboken may be switched over to New York or to the Erie and Pennsylvania stations in Jersey City. Caisson No. 3 is south of caisson No. 2, the three caissons making a triangle. In caisson No. 3 trains from the Erie and Pennsylvania stations are switched either to Hoboken or to New York. It was originally intended to use steel caissons, but the high cost of steel and uncertainty as to the delivery of material resulted in the decision to make them reinforced concrete with steel cutting edges, being the first of their kind. They were sunk to position and the shields then run into them, making in a unique way underground switch yards, and saving a large amount in cost and in time, the latter being of the utmost importance. It would propabably have taken about nine months and cost $75,000 to make one steel caisson. All the caissons were sunk under air pressure.

GREATEST DIFFICULTIES NOT APPARENT.

Perhaps the greatest, though not the most spectacular, feat in all the construction thus far completed was the building of the tunnels at the intersection of Christopher Street, Ninth street and Sixth avenue, in Manhattan. From this point two tunnels go east under Ninth street and two north up Sixth avenue. Here there was the elevated railroad overhead, the Metropolitan Street Railway lines on the street surface, and buildings on each side of the street. It was a problem similar to the intersections in Hoboken, just described, but in this case, of course, sinking a caisson was out of the question. To accomodate the two tubes coming up from the south and the four diverging to the east and north it was necessary to build an arch whose maximum width was 68 ft. The work was all in running sand and was done under air pressure. Two iron-lined tunnels were run through this intersection first, and the side-walls then built in. Openings were then made at the tops of the tunnels and timbering for strutting was carried up so that sufficiently heavy false work could be put in for springing the arch. After the arch was completed the two temporary tunnels were taken out. This work required the greatest ingenuity and care for at least eight weeks. Any accident to the timbering, any loss of the necessary air pressure, or any carelessness of the men, would have undoubtedly caused a cave-in, and the elevated structure and the surface lines, together with the streets and the buildings on each side, would have fallen into the excavation. Every square inch of the treacherous ground had to be protected by wooden sheathing the moment it was exposed, otherwise the vibration of the passing trains above would start the sand running. This part of the work was the last of the excavation necessary for opening the railroad to traffic, and although it was early in last December when the spring of this large arch was under way, it was finished so that trains could be operated on February 10, 1908.

It is proposed that the word "kelvin" be laid before the International Standardization Commission as the kilowatt-hour unit, thus honoring the memory of the late Lord Kelvin and giving a short expression for the kilowatt-hour.

RIGHTING AN OVERTURNED CAISSON

In Chesapeake Bay, two miles off the mouth of the Magothy River, at the entrance of the main ship channel to the City of Baltimore, there now stands the completed foundation for a large lighthouse. The erection of the superstructure is merely a matter of time and involves no difficulties or unforseeable contingencies, but the story of the foundation is one which cannot fail to interest the engineer, and even the general reader, inasmuch as the progress of the work involved a serious catastrophe the consequences of which were corrected by ingenious and unusual engineering arrangements. The account which follows is abstracted from the narrative of Mr. H. P. Kieffer.

Fig. 1 is a vertical section of the foundation as completed. The lower part of the base consists of a square wooden caisson measuring 48 ft. on a side at the bottom, 46 ft. on top and 21 ft. high, having the usual working chamber and air and dredging shafts. This caisson carries a cast iron outer cylinder, 45 ft. in diameter for the lower five courses, then rising in a conical shape for four courses, and then rising for three courses with a uniform diameter of 30 ft. to a trumpet-shaped top. The total height of the cylinder is 82 ft. 3 in., and the total height of the whole foundation pier is 103 ft. 3 in.

Work on the caisson was started in the spring of 1904, but on account of various delays it was not ready for launching until the middle of summer. During the launching the caisson ran off the ways and grounded in the mud. A dredge was brought into service and the mud was dredged away from the front of the caisson. The Baltimore ice boat and a number of powerful tugs were then attached to it and succeeded in getting it afloat. Two rings of flanged cast iron plates, each ring 45 ft. in diameter and 6 ft. 3 in. high, were bolted to it and the caisson was towed to the site.

The structure had to be sunk through 55 ft. of mud, a 4-ft. stratum of coarse sand and finally into about 2 ft. of fine sand, in which it was expected to come to rest. When the caisson arrived on the site on September 19, 1904, the contractors immediately began to fill the rings with concrete. Two more rings were added, making the cast-iron cylinder 25 ft. high. The water at the site of the lighthouse was 24 ft. deep and the caisson with the two rings on top drew about 23 ft., and was floating with the cutting edge just above the mud. This mud was so soft that a pile stood on its end sank 15 ft. into it of its own weight. It was the intention of the contractors to load the rings with concrete until the weight should cause the caisson to sink through the soft mud to the harder stratum below, after which it was intended to put on the air and sink the caisson by the ordinary pneumatic process.

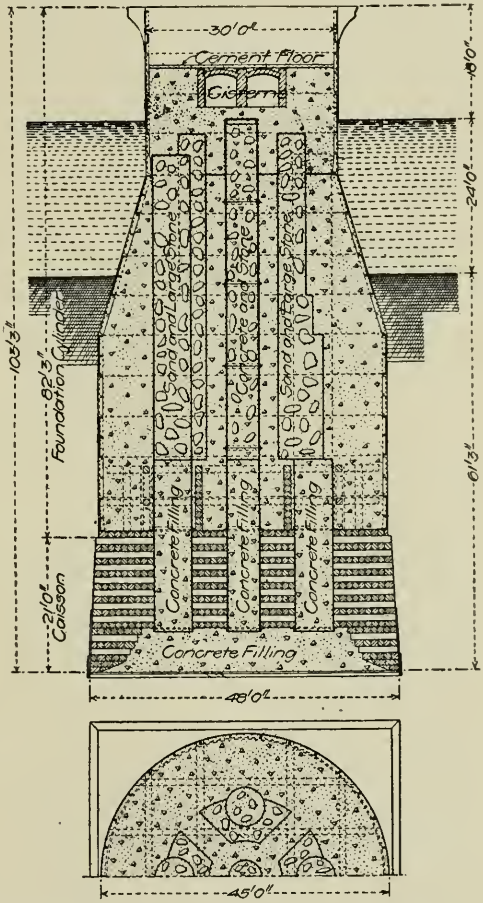


FIG. 1—VERTICAL SECTION OF FOUNDATION.

For the purpose of carrying on the work the contractors provided three barges about 200 ft. long, one of which was an old bark with all three masts in place and the others were old ferry boats. These barges provided quarters for a crew of about 150 men, and one of them was fitted with three boilers, two air compressors and other appliances necessary.

Owing to bad workmanship, the deck of the caisson leaked to the extent of about a two inch stream, and as the specifications required that the concrete should be laid in the dry, the leak and necessity of working in dry sections caused more delay. Finally concreting was started, and a layer about one foot thick was placed over the whole deck. The space inside the two lower rings was divided into three parts by two water-tight bulkheads 12 ft. high, running about north and south, after the caisson was anchored in position. Concrete was placed alternately in each of the outside pockets.

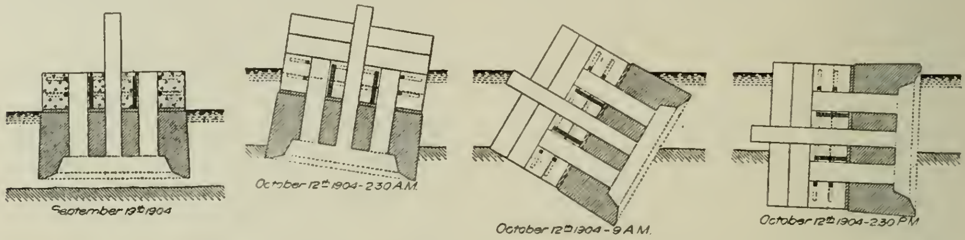

September 19th 1904
October 12th 1904 - 2.30 A.M.
October 12th 1904 - 9 A.M.
October 12th 1904 - 2.30 P.M.

FIG. II.—SUCCESSIVE POSITIONS OF OVERTURNING CAISSON.

When the concrete in the east pocket was 4 ft. 9 in. above the deck, that in the west pocket was 2 ft. or more below, and the whole structure took a list to the east, and more concrete was rapidly thrown into the west pocket, until it reached the height of 13 ft., when the top of the structure began to move to the west.

This point was reached on the morning of October 12, when a gale came on from the northeast, in which direction the site is exposed to the whole sweep of Chesapeake Bay, and before night the caisson lay with one side 46 ft. below the surface of the bay, and the other just awash, while the contractors' boats were blown ashore, and lay among the breakers, two miles to leeward. Fig. 2 shows successive positions of the caisson.

The next day the contractors made an assignment. They claimed to have expended up to this time about $70,000, much of which, however, was for plant and equipment. The loss of the caisson was caused wholly by bad judgment, and entire lack of the most ordinary precautions. If, instead of mooring the caisson with a few anchors and attaching to it the three large and clumsy barges, all of which, including the caisson, bobbed and wabbled around with the waves, a half dozen dolphins of heavy piles had been driven, and the caisson and barges had been properly moored to these, it is probable that the whole equipment would have ridden out the gale of October 12, although the overloading of one side of a structure whose center of gravity was necessarily high, was a fatal error.

The winter and spring of 1905 was wasted in discussions between the receiver and the creditors over ways and means to raise the caisson and complete the work. Contractors, engineers, wreckers and experts of all kinds were brought in, all to no purpose; and finally in June 1905, the Goverment declared the contract in default, and called on the United States Fidelity & Guaranty Company, surety on the contractor's bond, to complete the work.

In August 1905, a subcontract was entered into between the surety company and a New York contractor, who after working the rest of the season, and taking off some of the iron plates, but accomplishing nothing of real value, was ordered off the work by the Goverment, and in the spring of 1906 the work was taken up by the surety company, under the plans

After a careful study of the problem, it was decided that the best way to right the overturned structure was to construct a tower and direction of Mr. Chas. F. Wood. or derrick on the caisson, and suspend thereon enough lead to shift the center of gravity to a point near the toe or cutting edge of the caisson, and then apply sufficient force through hoisting engines and derricks to revolve the structure through a quarter turn.

In order to insure stable working conditions, and eliminate the chance of disaster at a critical moment, a wharf, Fig. 3, was constructed around three sides of the caisson, 75 to 80-ft. piles being used in this structure. On this wharf were installed the boilers, engines, compressors and other plant, and equipment, including two 25-ton derricks, and the houses for the protection of the machinery and men. To secure fresh water for the boilers and other purposes, a 6 in. artesian well was driven into the bottom of the bay, about 184 feet below high water, at which depth a stream was tapped under a head of about 6 ft., which overflowed the pipe into the bay, like a fountain. This well furnished practically all the water used on the work, and at the time of greatest activity supplies nearly 30,000 gallons per day. The water from the well being somewhat impregnated with sulphate of iron, during the latter stages of the work, a homemade iron pipe condenser was used to supply water for drinking and cooking purposes. The value of the well can be gathered from an experience in bringing down one scow load of water, which cost $2.50 at Baltimore, but which for towing and other charges represented a cost of $69 when delivered on the work, and was used in one day.

A very interesting feature of the well driving operation was the bringing up, from about 160 ft. below the surface, the water washed sand and gravel of an old beach. Along with the sand and other debris, came many pieces of wood, worn smooth by the action of waves, and showing the borings and remains of sea insects. The color and texture of this wood was almost that of ebony, but the grain of the wood was that of pine and it cut with a knife almost like charcoal. Evidently it was the remains of a past geological era, when the beach of the Atlantic was near the western shore of Chesapeake Bay, and before there was such land as the peninsula of Delaware, eastern Maryland and Virginia.

The first operation on the caisson was to replace with divers some of the plates removed by the sub-contractor above referred to, the second and third rings, which had been partially taken off, being re-completed. The tower was built on the side of the caisson seven lengths of 2-in. plow steel cable was drawn under and around the rings and both ends of each carried over the top of the tower and to the end of the boom. One hundred and twenty tons of pig lead was bunched into ten weights of twelve tons. "I" beams were slipped through three of the dredging shafts, and by means of saddles given a bearing on the upper side at the deck of the caisson, and on the lower side at the roof of the working chamber. One 12-ton weight was hung on the center spud, and one of the large derricks above referred to was attached to each of the side spuds. Four-part lines reeved through double blocks were carried to the front, rear, and side from the top of the tower on each side and the leads taken to the six drums of three double drum engines. A trench was pumped in the mud all around the caisson down to the lower edge, and the mud was partially removed from in front of the caisson.

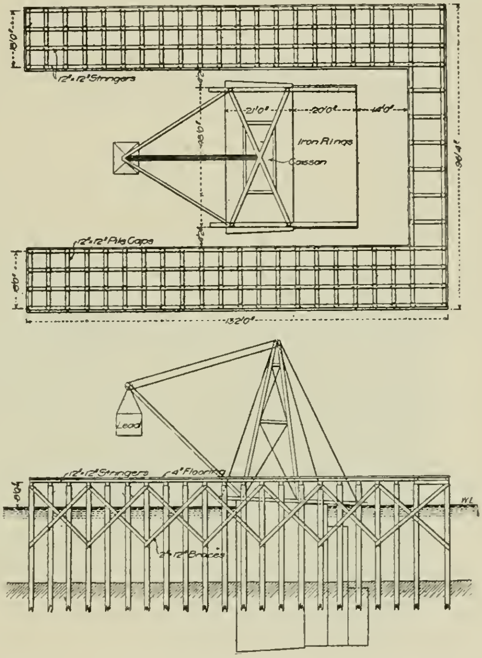


FIG. III.– OVERTURNED CAISSON WITH WHARF BUILT AROUND IT.

In addition to the force applied directly to the caisson itself through the spuds above described, extra precautions to prevent the iron rings and concrete pulling away from the woodwork at the lower side, by reason of an unequal pull on the iron and wood, was taken by tying the rings and caisson together with 1¼-in. cable and turn-buckles. Hooks were made to go over the upper flanges of the third course of plates and over the cutting edge of the caisson. Forty of each were used, and the pairs fixed together with cable, drawn up with turnbuckles, as above, so as to tie the iron and timber into one mass, and insure the turning the structure as a whole. Most of these ties were placed and made up by divers.

Nearly two months were lost waiting for two large derricks, which were bought for May delivery, but finally everything was declared to be ready and the first effort to move the caisson was set for the next day.

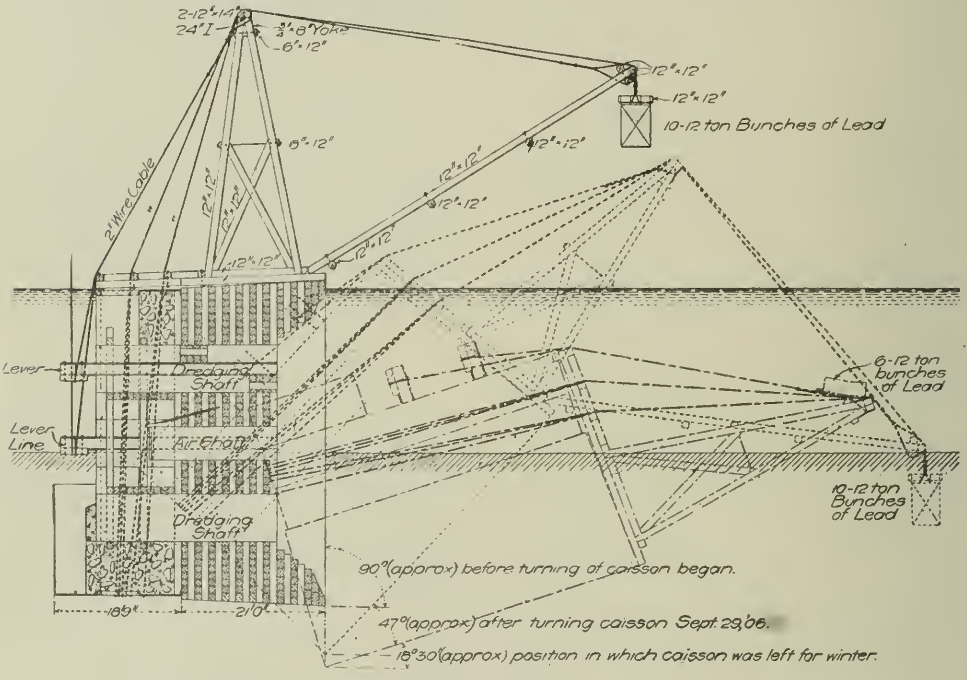

2-12"×14"
24" I
3/4"×8" Yoke
6"×12"
8"×12"
2" Wire Cable
12"×12"
12"×12"
12"×12"
12"×12"
12"×12"
12"×12"
12"×12"
12"×12"
12"×12"
10-12 ton Bunches of Lead
Lever
Lever Line
Dredging Shaft
Air Shaft
Dredging Shaft
18'9"
21'0"
6-12 ton bunches of Lead
10-12 ton Bunches of Lead
90°(approx) before turning of caisson began.
47°(approx) after turning caisson Sept. 29,'06.
18°30'(approx) position in which caisson was left for winter.

FIG. IV. SUCCESSIVE POSITIONS OF CAISSON AND TOWER IN RIGHTING.

In estimating the weight, displacement, leverages, and other factors, it was calculated that 100 tons of lead, acting with a lever arm of 58 ft. would bring the mass in equilibrium on the axis of the center of gravity of the wooden caisson. The additional 20 tons was added to insure that the neutral axis should be between the center of gravity, about 7 ft. from the deck, as planned by the United States Lighthouse engineers, and the cutting edge of the caisson.

On Friday, September 29, when 95 tons of lead had been hung in place, that weight, aided by about 3 tons weight of boom and 2 tons of cable, caused the structure to move forward about 1/16 in. per hour. Late that evening the balance of the lead was hung. A test was made with the hoisting engine, and the mass moved forward about 3 ft. Then to prevent the forward movement, which kept on at the rate of more than 1 in. per hour, the lines to the rear from the top of the tower were tightened and everything held in place, until the arrival of the invited guests at noon the next day.

On Saturday, September 30, the president of the company, the lighthouse officials and guests arrived. At 1 P. M. the stops were cast off the lines, the word given, and the structure turned through about 47 deg. in about as many seconds. Everything worked out just as planned and before night the divers were down hooking on to the lead weights, which had brought up on hard bottom. During the next few days, one by one, the 12-ton bunches were lifted, and laid on top of the tower. The cables to which the lead was attached were pulled aside; the boom released and floated out of the way, large centrifugal pumps with jets attached to the suction pipes were started, and the mud under the high side removed allowing the caisson to settle slowly into the bottom.

Cold weather interrupted the work about December 1. All the machinery was removed from the wharf because of the possibility that the ice, which in this particular part of the bay is very troublesome, might carry it away. The wharf stood, however, and except for the breaking off of a few piles, everything was found intact when work was resumed in the spring of 1907.

Early in April, the machinery was again installed on the wharf. One of the barges was kept afloat and became one of the most useful helps on the work. The old hulk was never laid off the job, being moved round and round the wharf to find a lee when storms blew, all of which it outrode gallantly, and there was not a point on the wharf where her 70-ft. boom could not be brought to bear to lift and perform whatever work the fixed derricks were not able to reach. The two large derricks previously mentioned were replaced by a tower, and the two 12 x 12-in. booms with three and four-part lines for lighter and more rapid work.

The tower was removed from the side of the caisson; the 2-in. cables were withdrawn from around the rings; the spuds were taken out of the dredging shafts; pumping was resumed, and the plates of the fourth, fifth, sixth, and seventh courses of iron rings were put in place, most of them under water, with the aid of divers. This brought the structure above water. A 1¼-yd. cube concrete mixer was installed, and ten 20-in. 65-lb. 60-ft. I beams were thrown across from the two sides of the dock, and floored to secure additional space. A cement house and other structures were built. Temporary wooden doors were fitted at the bottom of each of the four dredging shafts and concrete to the depth of about 6 ft. was deposited in each by means of a bottom dump bucket. While this concrete was settling additional sections of the air shaft were added to bring it above water, and preparations were made to pump out the cylinder.

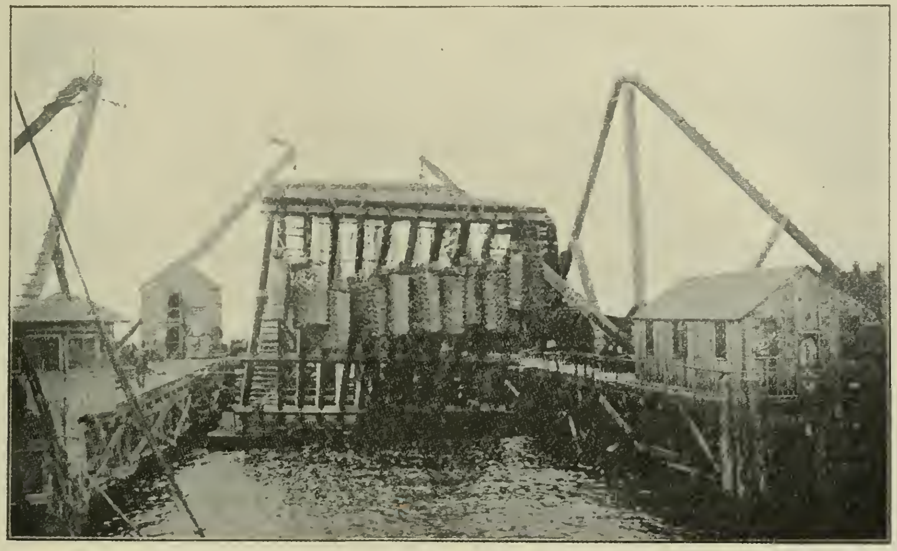


FIG. V.—LEAD WEIGHTS HUNG ON TOWER OR DERRICK OF CAISSON.

In turning the structures, the cutting edge of the caisson, which at the start was about 46 ft. below the surface, sank about 11 ft., the movement being forward and down at the same time, so that the deck of the caisson was about 36 ft. below the surface of the bay, when the time came to empty the cylinder of water. The displacement of the cylinder was about 50 tons per foot of depth, and weight to the extent of about 1800 tons had to be provided to prevent the structure from jumping out of the water like a big cork. This was provided by rubble boulders weighing from ½ to 4 tons each, which were lowered into place by derricks and placed by a diver. Several scowloads of sand also were thrown into the cylinder. Old sails were wrapped around the outside of the cylinder, wound with many turns of hemp line, hove taut with an engine, and the pumps were started to clear it of water.

At this point came one of the most troublesome and expensive difficulties of the whole operation. It had not been considered that emptying the cylinder presented a serious problem, but on trial with a 10 x 8-in. Lawrence centerfugal pump with an 8 x 8-in. engine, it was found that while the water could be lowered about 3 ft. in about 11 minutes, it returned at the rate of 300 cu. ft. per minute, and in 15 to 16 minutes from the time the pump stopped the water level inside and out was the same. Experiment after experiment was tried but it was like trying to pump out the bay.

Finally a new canvas, 37 x 150 ft., made of No. 4 duck was secured, cut to fit the batter of the sixth course, and well roped around the edge. This was drawn around the cylinder and tightened up with an engine. Strips of 1 x 6-in. wood were put along the vertical joint inside and outside, and the two strips nailed together every 6 in. by a diver. This reduced the leakage more than half, but the flow was too strong to permit laying concrete. Then about 4,000 cu. yd. of mud were brought from one of the dredges working in Baltimore harbor and dumped in the slip between the points of the wharf, after which a ¾-yd. clam-shell bucket was used to bank the mud around the cylinder. By this means the leakage was reduced to insignificant proportions, and thereafter was handled conveniently by a No. 3 Emerson pump, running an occasional stroke. Practically all this trouble, delay and expense was caused by the removal of the plates, which was the only thing done by the sub-contractor who attempted the job after the failure of the original contractor.

Each of the 45-ft. diameter ringes was made up of thirty cast iron plates about 5 ft. x 6 ft. 3.-in. x 2-in. thick. These plates had 8-in. flanges all around and were bolted together by 2-in. bolts.

After the leakage was surmounted, the cylinder was quickly filled with concrete up to the middle of the sixth course, the large stone being moved from side to side until it was placed on the concrete. At no time was the weight allowed to drop below a safe load required to hold down the empty shell.

The pump was continued in service for nearly three weeks, almost without a stop and with practically no attention, until the concrete was brought above the surface of the bay, a sump being left all the way around the deck of the caisson. Iron pipe channels were left at various points leading to this sump. After the pump was removed, the sump was closed except for a 2-in. pipe connection to which a grouting machine was attached, and the sump and all of its channels pumped full of grout under an air pressure of 140 lb. The cubic contents of the sump and its connections were very carefully calculated, and a sufficient amount of grout was forced in to entirely fill the space. Thereafter the surface of the concrete was never allowed to get below water level. During the period when concreting was going on, the air compressor plant was thoroughly gone over, an electric light plant was installed and men and material locks were secured. A hospital lock was fitted up and a physician experienced in the care of men working under compressed air placed in charge as medical director.

The class of labor was rapidly changed. Sand hogs were brought from New York under experienced foremen. The locks were placed, air turned on and the sinking commenced and continued without interruption until the end.

Some of the clay stratum on which the caisson rested when the air was turned on, was taken out with shovels and a bucket, but most of the material was blown through a 5-in. iron pipe carried up in the air shaft and turned overboard. At its end it was fitted with a short length of 4-in. suction hose, and a 4-in. plug cock served to close it when necessary. The material was washed to a sump by one or more jets from a 2½-in. fire hose nozzle supplied with water by a pump on the dock.

The men worked in two shifts, varying from four hours each at the beginning to one hour each at the end. The air pressure varied from 25 to 40 lb.

One of the serious troubles the men had to contend with at the start of the air work was sinking through an old oyster bed or bar at a depth of about 60 ft., which evidently had once been the bottom of the bay. The oyster shells, which were very numerous, clogged the blow pipes, cut through rubber boots, gloves and skin, making the progress slow, difficult and painful.

SMALL PIPES FOR AIR LOCK.

The material lock was fitted with large connections and valves, so that materials could be locked in and out rapidly, but the man lock, which was on the side and entirely separate from the other one, was fitted only with a ¾-in. valve, and so rapid ingress and egress was impossible. It is common practice on similar work to use as large a valve as 2-in. This condition caused considerable complaint on the part of the men at first, but they were soon accustomed to waiting patiently for decompression.

During the long delay between the closing of the caisson and the putting on of the air, the teredo had been very busy in some of the exposed parts of the caisson. It was necessary to remove some of the bulkhead timbers within the rings entirely, but most of those in the working chamber stood up to the work, the holes being afterward pumped full of grout with the grouting machine. The caisson itself was strained slightly by the turning, and a few of the caulked joints in the working chamber opened slightly.

No special difficulty was experienced in mudding up these leaks, although they required constant attention, and, together with the worm holes, caused a considerable blowout of air on the southeast corner. This leak was not regarded entirely as an objection, as it served to keep the air in the working chamber in good condition, and taken as a means of ventilation not requiring more air than would have been otherwise wasted, no strenuous effort was made to close it. In addition, the porous sand stratum below the blanket of mud at the bottom of the bay absorbed a large volume of air, and in calm weather the bubbles of air could be seen rising in all directions for a long distance from the work.

After the concrete was started the work never stopped night nor day until the working chamber was filled with concrete, sealed and the air taken off. During 1906, and until August, 1907, the work was carried on with a small force working only one shift. The main volume of concrete was placed by three shifts working throughout the 24 hours, and for considerable periods, the material handled averaged a cubic yard in each six minutes. After the concrete reached the surface of the water, one shift easily placed the material as fast as the caisson sank.

In filling the working chamber all but the last few yards of concrete at the bottom of the central air shaft was dropped through two 12-in. diameter iron pipe shafts leading through the north and the south dredging shafts. These pipes were installed when the temporary doors were put in the shafts, and built in the concrete as it came up. A 12-in. Jenkins straightway back-pressure valve was placed at the top of each to hold the pressure and act as a lock. A wooden target with a rubber gasket was used at the bottom of the pipe to hold the air, when the top valve was opened to fill the pipe with concrete from the hopper platform. Means were provided to equalize the pressure with the main air shaft, and the arrangement worked reasonably well. Some trouble was experienced from stoppages due to the long length and small diameter of the pipe. It proved that for tubes for this purpose, particularly if as long as these, 84 ft., the diameter should be not less than 16 in., and 18 or 20 in. would probably give better results.

Outside of the small boiler on the barge, four boilers were used; two of them were of the marine type of 125 h.-p. each and the other two were verticals, aggregating about 100 h.-p. Two Class A straight line Ingersoll-Rand compressors were used, one high-pressure machine of 1,250 cu. ft. per minute, and the other a low-pressure machine of about 900 cu. ft. free air per minute. Air receivers and an air cooler made up of 6-in. pipe carried through a tank of water under the pier were provided, and the conditions in the caisson so far as the air was concerned were at all times pleasant and agreeable.

A 12½-kw. generator and engine was installed. The lights for all the houses and around the outdoor machinery, and also those in the locks, shafts and caisson, as well as the arc lamps for general illumination, were attached to this machine.

The number of men employed during the last few weeks average 115. There was no special sickness and only two or three men were sent away from the wharf on that account. No one was seriously injured and there were but two slight casualties during the progress of the work. The reasons for this happy condition Mr. Wood attributes to the care exercised in picking out and looking after the men, to the short shifts, which aided in keeping up their vitality, and to the entire lack of means for dissipation on the part of all employed. The rest and food were factors, as was also the care taken in securing a pure air supply; the ventilating and lighting of the air chamber also aided. *The provision of only small openings on the man lock*, which made it absolutely impossible for any of the men to do otherwise than observe the rules of the best practice for compression and decompression in entering and leaving the caisson was undoubtedly of value.

Taking into account the number and character of the men employed, the length of time for which they are engaged, the hazardous nature of the work, the remote location and narrow limits within which a large number of men labored and were housed, fed and cared for, the operation is remarkable, and in this phase of it Mr. Wood takes a great deal of pride. He also specifies by name a considerable number holding responsible positions who co-operated with him, and in conclusion aknowledges also his great indebtedness to the men who, through long nights and days of strain, stress and struggle, in intense heat and bitter cold, in calm weather and with gales blowing, often at the risk of life and limb, performed their part. As he expresses it: "No matter what his ability, no man gets very far or does very much except through the loyalty and co-operation of those on whom he depends to execute his ideas. Therefore after everyone else has been given full credit, what is left you may award to me."

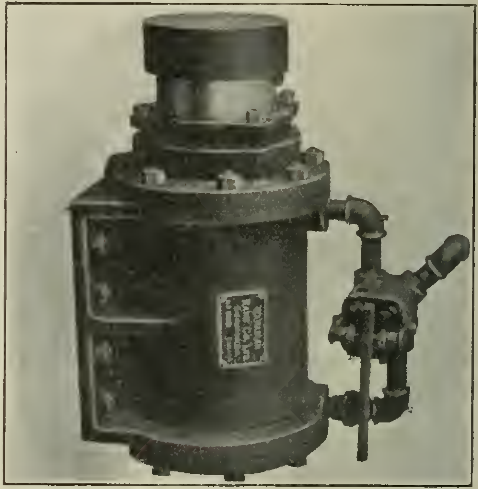
A WATER CARRYING DEVICE

A sugar refinery at Crocket, California, is so situated that while it has the ocean to draw from there is no supply of fresh water, which it of course requires in considerable quantity. It has had built for it a large barge, and this barge is towed up the river where the water is fresh and then allowed to fill until it is submerged almost to the deck. It thus brings to the refinery to be pumped out about half a million gallons per trip.

If this barge had an air tight deck and hatches to fasten down what a simple thing it would be to lead a compressed air hose to form a pressure on top of the water and then have another hose by which the water could be delivered to storage tanks anywhere about the plant as required.

A SPECIAL PNEUMATIC RAM

We show here a special pneumatic ram built by the Canadian Rand Company, for the Dominion Car & Foundry Company, Montreal.



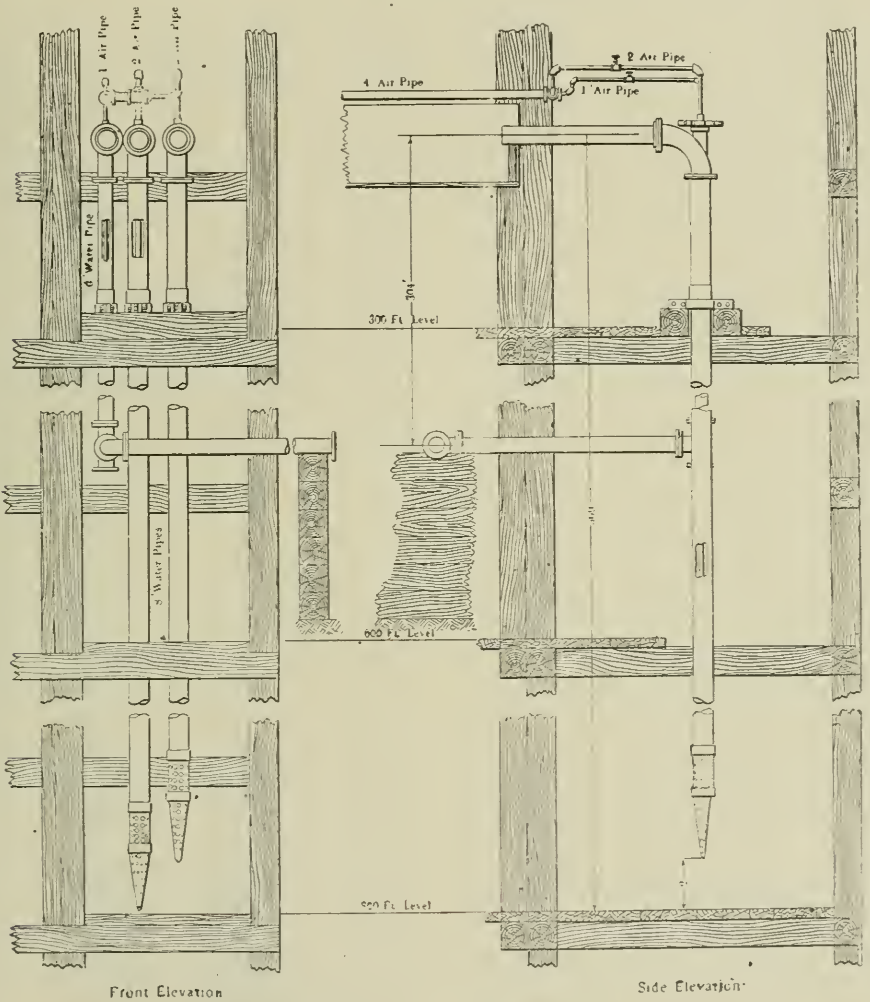
A SPECIAL PNEUMATIC RAM

It is used for pressing brake heads on the brake beams. The cylinder is 10 inches diameter allowing the plunger a travel of 10 inches, and the usual shop air pressure of 80 lbs. is employed. The press or ram is mounted on a steel frame with a post at the opposite end, the space between the post and the ram being just sufficient to take in the brake beam. One operator controls all the operations of the ram by the single lever shown, while another puts on the brake heads, first the one next the post and then the one next to the ram. The valve is dust proof and air balanced, with four ports admitting the air to or discharging it from either end of the cylinder. Instead of drawing in air from the shop, admitting with it dust and dirt, the air is taken only from the receiver for the forward stroke and for the backward stroke the same air is exhausted from one end to the other, thus preventing dust from entering the cylinder.

THE AIR LIFT IN UNWATERING THE HOMESTAKE MINE

The episode of the fire which occured last year in the Homestake mine at Lead, South Dakota, has been narrated in graphic detail by Mr. Bruce C. Yates, assistant chief engineer of the Homestake Mining Company, in the *Engineering News*. The mine was of large extent and contained an immense quantity of timber distributed through a labyrinth of stopes at different levels. The entire stope area in feet was a mass of loose rock and timber with also numerous bulkheads built years ago to support pillars of ore while adjacent stopes were being worked. The fire began on March 25, 1907 and was from the first beyond control. After exhausting all expedients the mine was flooded, and then came the unwatering in order to resume mining operations. This was done mostly by bailing with skips in the several shafts lifting 1,000 gallons at a time, some of them 2,000 gallons.

A system of air lifts was installed at the Ellison shaft, which proved to be of great assistance. Two 8-in. pipes were lowered from the 300-ft. level to the 800-ft. level in the pipe compartment, and a 2-in. pipe was put inside of each 8-in. pipe extending down 240 ft. below the discharge. The 8-in. pipes had a conical end at the bottom, provided with 2-in.



AIR LIFT FOR UNWATERING HOMESTAKE MINE.

holes in the surface of the cone. The area of these holes is about 2½ times the area of the pipe cross sections. On the lower end of the 2-in. pipe were pieces of pipe about eight inches long with numerous small holes in the circumference, pointing upward at an angle of 45 deg., the ends of the pipe being closed with a cap. The discharge ends of the water columns were provided with special curved elbows, having flanged openings through which the air pipes entered. Fig. 4., shows the arrangement of piping for these air lifts.

A 6-in. pipe, which is a part of the mine-fire service and which connects a tank on the 200-ft. level with one on the 600-ft., was taken apart at the 300-ft. level and a 1-in. air pipe was lowered inside. This pipe threw considerable water until the water was lowered 200 ft., although there was one tee and one elbow at the lower end. Both 8-in. water columns were made of screw-connected pipe, put together a length at a time, and lowered by block and winch. Air at 80-lb. pressure was first used, but when the air pipes were lowered, air at a pressure of 85 lb. was turned into one of the columns.

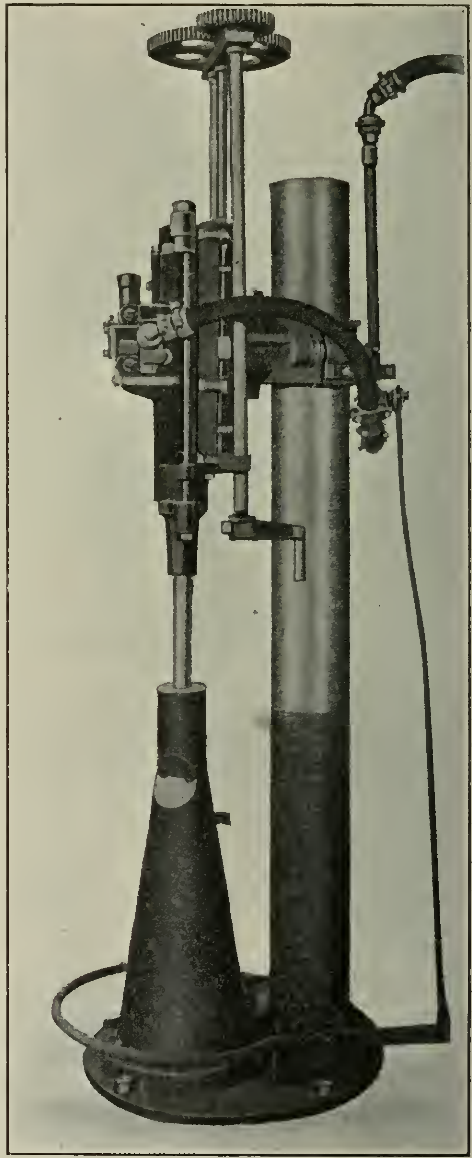
When the air-lifts were discontinued the high-pressure line was lifting water 336 ft. with a submergence of 171 ft., and the low-pressure line was working against the same head with a submergence of 135 ft.; the two together were raising about 600 gal. per min. When the three pipes were at their best efficiency they raised 4,397,000 gal. in 24 hours, with the water level standing 87 ft. below the discharge and submergence of the air lines of 157 ft.

The total amount of water pumped from the mine by the air lifts was 83,469,000 gal. The average per day, during 31 days, was 2,692,550 gal. The total amount hoisted and pumped from the mine during the time was 309,891,500 gal., of which the air lifts raised 26.9 per cent. The best record for 24 hours made by all of the skips was 8,724,000 gal., and the Ellison shaft alone hoisted 4,500,000 gal. in 24 hours from about 185 ft. below the 300-ft. level.

A NEW PNEUMATIC FORGING HAMMER

The half tone shows a handy pneumatic hammer for blacksmiths, built by the Canadian Rand Drill Company. The following notes regarding it are by Mr. T. Chabot, of the Sherbrooke shops of the company.

We find the new hammer better than the belt driven style in that it is more easily controlled and its range of work is practically unlimited. We use it on all kinds of comparatively light work, i. e., sizes ¼ in. to 2 in., round or square. It is used to great advantage



A HANDY PNEUMATIC HAMMER.

on welding springs and drawing out ½ in. to 1¼ in. sizes.

It is arranged so that the valve is operated by a treadle, leaving both the operator's hands free to attend to his work. The principal advantages of the hammer are that the operator can control the blows so very easily, and this with the foot, leaving him free to use chisels, formers, etc., under the hammer, without a helper; the facility of adjusting the hammer to the work in hand, which is done with a few turns of the feed handle; the ability to change the stroke from 8 in. to 1 in. or vice versa, without interrupting the work.

Some of the jobs we keep it busy with are: Drawing out springs, cold chisels, picks, bars, lathe tools, etc., and welding and drawing out stock to 1¼ in. Not least worthy of mention is the space occupied, the hammer being set on a concrete base only 30 in. in diameter.

We are preparing to use it in upsetting and forging bolts in a bolt vise. This will be done by putting a safety clamp under the column clamp, which will permit the hammer to be swung around over the vise for upsetting and back again over the anvil to forge the head to hexagon or square.

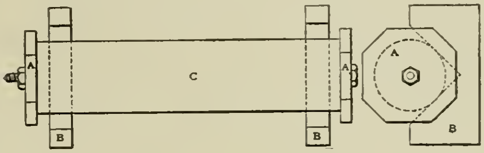
EARNINGS OF A DRAINAGE TUNNEL

Mr. T. R. Countryman, engineer of the new Cripple Creek drainage tunnel, in a paper before the Colorado Polytechnic Society, gives some interesting matter concerning the value of the El Paso tunnel completed in 1903. He says:

"Assuming the average cost of lifting 1,000,000 gallons 600 feet in the Cripple Creek district to be $125, then the El Paso tunnel has earned to date fully $1,000,000, and it is still at work. It works every minute of the day and every day of the year. There is no expense connected with it, and no flooding of levels on account of labor strikes or accidents to machinery. This tunnel has lowered the general water level of the district, as shown by the subsidence of the water at the Elkton shaft, a total of 160 feet. Perhaps the average reduction would not be so much."

It is stated in the paper referred to that the new Gutch Park or Roosevelt tunnel, now in progress, will cost 20 per cent. more than first estimated, but:

"Even should it cost 100 per cent. more the mine owners cannot afford to abandon it, for it will in the end save many times its cost in pumping alone. It will also save very largely in other mining costs, particularly labor. The completion of the tunnel will mark the beginning of another era of activity and prosperity for the Cripple Creek district."



CHEAP AIR HOIST CYLINDERS

A contributor in a recent issue of the *American Machinist* says that he once received an order to build a number of air hoists to be used in a large railroad shop, taking for the purpose such material as he could pick up around the shop. He found some pieces of 8, 10 and 12 inch pipe and cut them into 6 foot lengths. He cut two hardwood blocks, *A*, 12 inches square and 1½ inch thick, bored a 1 inch hole in the middle of each, filled a pipe about half full of scrap and sand, bolted the blocks, *A*, to the ends by a bolt through the middle and then laid the pipe in the two cradles, *B*, as shown. The pipe was then driven by a belt around the pipe and over the line shaft for about 10 hours, and the inside was scoured out true and smooth enough for use. The hoists using these cylinders are said to have given good service and the cup-leather piston packings lasted a long time. We might suggest that if an inch or so had been cut off of each end of the pipes after the tumbling process it might have been an improvement, as the scouring could not have been fully effective in the corners.

The Cape to Cairo Railroad in Africa only requires the completion of 700 miles to enable travelers to make a connected journey by rail, lake and river from Cairo to Cape Town.

THE SAND-BLAST MACHINE "AN ELECTRICAL GENERATOR."

By B. O'Reilly.

We have had a sand-blasting apparatus in operation for some time, in the form of two cylinders made of sheet steel. These cylinders are arranged vertically, the larger one being uppermost. The lower one forms both a column to support the whole machine and a chamber to contain fine, sharp sand. The two chambers are connected by a length of rubber hose about 1½ inches internal diameter. At the end of the hose which is inside the upper chamber there is a nozzle of cast iron, the bore being about ¼ inch.

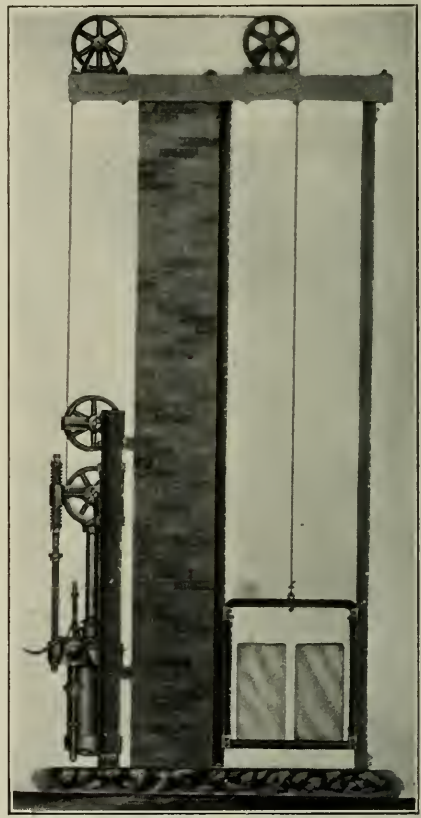
The machine is worked by compressed air, of an average pressure of 5 pounds. The compressed air forces up the fine sand from the lower chamber, through the rubber hose and nozzle into the upper one. When operating the machine, the hands are inserted through two openings in the upper chamber. One hand holds the tool which is to be cleaned, while the other, holding the nozzle, directs the current of air and sand in the required direction. The operator observes the progress of the work through a small window on a level with his eye.

A man who was using the machine complained that he had received, or imagined he had received, a curious kind of blow or shock to his arms—nothing serious, but sufficient to make him note the fact. A day or two after a pipe fitter, who had some alterations to make, laid his hand on the rubber hose. He received a shock which startled him. Another man who was near, grasped the hose, when he at once received an undoubted shock. I distinctly saw the spark and heard the sharp crack which accompanies a discharge of static electricity. As a further proof that the hose was electrified, I took a long thread from a piece of cotton waste; this was attracted by the hose, as were also other light substances.

A water-gage glass tube was slipped upon a round steel rod so that about 12 inches of the steel rod stood out at each end of the gage glass. Holding the gage glass in the left hand, the steel bar was fairly well insulated, while one end was sand blasted; so long as the jet continued to play upon this end, sparks could be drawn from the other. The use of dry hot sand gave the best results.—*American Machinist.*

PNEUMATIC ICE HOISTS

In a modern plant producing ice artificially an ice storage house is an important feature, especially in the interest of profitable operation. It enables a plant of smaller capacity to produce the year's supply by running continuously, under the most economical conditions and at its best rate of production for nine or ten months of the year with a shut down in the winter for general overhauling and rejuvenation. With a peak demand for 100 tons per day in August a 50 ton plant may be quite sufficient and better than a larger one for the year's total output.



PNEUMATIC ICE HOIST.

We illustrate in Fig. 1, an ice elevating and lowering machine especially designed for this service. As all ice plants have a constant supply of compressed air the apparatus is economical, to instal, to maintain and to operate. No explanation is necessary as to the design of the device. By a simple adjusting screw placed convenient to the operator the level at which the cage stops may be raised or lowered according to the height of the ice in the house. The elevator of course is used as well for taking ice out as for putting it into the house.

Fig. 2 shows a double horizontal hoist allowing two cages to be operated at the same time. These are normally for hoisting or lowering ice between fixed levels, as for icing cars or for raising ice to a loading platform from which it passes down inclines to different parts of the plant. The hoisting cylinders are not necessarily placed in the positions shown but may be located anywhere from which the rope may be strung over suitably located sheaves to the cage. Plants have been installed with as many as six cages in different parts of the building all operated by one hoist. These hoists are built by the Curtis & Co. Manufacturing Co., St. Louis.

AVOIDABLE COLLIERY ACCIDENTS

The Colliery Guardian, of London, speaks in severe terms of recent coal mine accidents in the United States. The authenticated reports of these, it says, make very interesting reading from many points of view, not the least important of which is the fact that the majority of these accidents form object lessons as useful for practical purposes as if they had been performed for the sake of experiment. Sad as has been the loss of life in connection with them, sadder still is the story which they unfold of the conditions prevailing in many of the pits of the United States, which are worked, in too many instances, under circumstances which positively court disaster.

Let us, for example, take the Monongah explosion, the precise origin of which still remains obscure, although there seems to be an agreement as to many of the facts of the case. The mines were stated to be well planned and fairly well ventilated, but were dry and dusty. Gas was present, but not in large quantities, and naked lights were used. Coal-cutting machines were largely used,

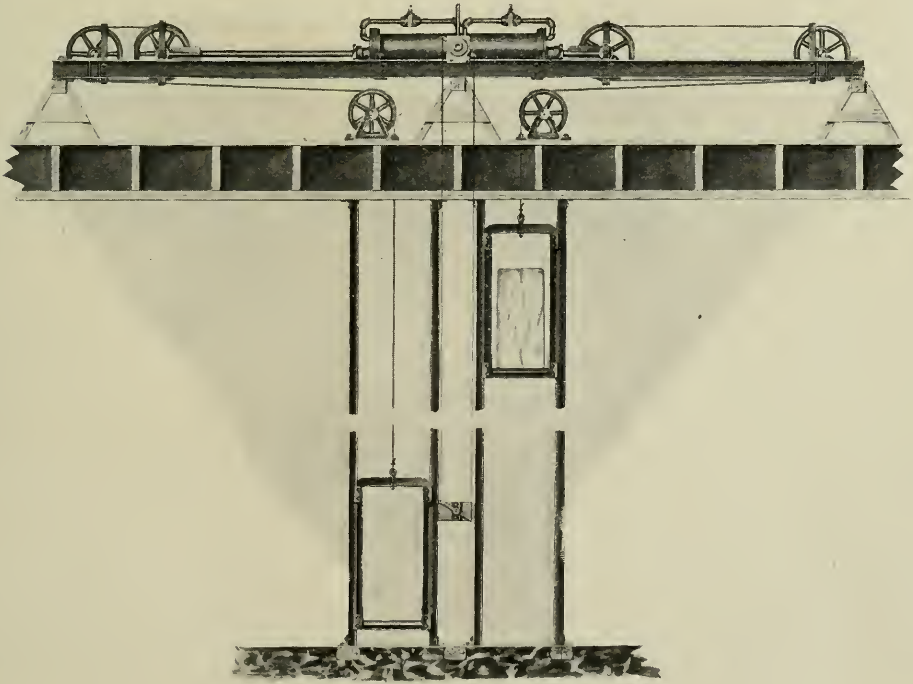


FIG. II.—DOUBLE ICE HOIST.

each machine in making one cut producing about one car-load of dust. Miners were supposed not to fire shots until twenty minutes after a cut had been made, but the shot-firing was often carelessly done, and black powder was used, sometimes in the coal itself. Naked wires carrying an electric current of 280 volts were present in the workings. Some sprinkling was done occasionally in the main entries, but little or no attempt was made to remove dust from the mine.

It would be difficult to find a combination of circumstances more favorable for the production of an explosion. It is a question whether it is worth while even to speculate upon its immediate cause. A somewhat strong body of opinion exists that it was the result of a runaway trip of wagons, and it may be worth while recording the fact that runaway trips had on two previous occasions raised such clouds of coaldust that ignition ensued and fires were caused. Something very similar took place last autumn in a pit worked by the Union Pacific Coal Company, at Rock Springs, Wyoming. Here six cars broke away down an incline of 1 in 5, crashed into a trip of full cars, and raised a dust cloud which was immediately ignited by the miners' lights, burning the men more or less, but fortunately without any violent explosion taking place. Whether such dust explosions are violent or not must necessarily depend upon the relative proportions of dust and air. In the case of the Monongah disaster, however, there is an equally strong opinion that this was an ordinary case of a blown-out shot igniting dust, perhaps in the presence of a little gas.

But, as we have said above, what matters the immediate cause when there were so many elements of danger in this pit. The inspectors who report upon this accident refer in detail to many of these, such as the excessive dust made by chain coal-cutters, the powerful charge of explosive required to break down the coal, the large amount of electric current used in the pits, the careless methods of shot-firing employed They also criticise the methods of working the pits. The seams are thick, and are worked in single cuts instead of in two benches. As many as eight parallel main headings were driven in the seams, forming special storage chambers for mine dust, and the fact that two separate mines were connected together underground is held responsible, as at Courrières, for large addition to the number of the dead. The Yolande explosion, in which fifty-six men perished, repeats a similar tale. There was gas in the pit; this gas was ignited by an open lamp; coaldust enabled the flame to be conveyed through the workings. After the disaster the company adopted a set of rules and regulations which the inspectors state are the same they have for the past five years been urging the managers to adopt.

WIRELESS ELECTRIC POWER TRANSMISSION

The Paris *Figaro* has published information of an affair which has already laid contribution on financial circles in Paris, and has, perhaps, also occupied foreign capitalists. It appears that the matter at issue was an alleged invention of a Lyons workman, who claimed to have discovered how to transmit electric power by a wireless system. As it was to be possible by means of this discovery to drive machines at any distance, it will be understood that the invention promised to create a revolution in technical work. In fact, credulous persons were found who provided money for the establishment of an experimental station, and who endeavored to gain over large capitalists in favor of the scheme. According to the inventor, a villa near Marseilles was converted into a power station, and invitations were issued for the attendance of a number of bankers and engineers to witness the proposed experiments. Everything was kept as secret as possible in order to assure the utilisation of the invention solely by the participants. The world was to be surprised, the Paris paper declares, but in a different way from that which was predicted. One of the engineers present made an examination, and it turned out that the table from which the inventor wished to transmit power into the world had by means of concealed conductors been brought into connection with the electric lighting mains of Marseilles. The power which was apaprently to stream forth from the mysterious boxes on the table was simply produced by dynamos in the usual way.

COMPRESSED AIR
AND EVERYTHING PNEUMATIC
Established 1896

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THE NEW YORK PROBLEM

One of the easiest and one of the commonest things is the lamenting of our lack of foresight, or rather, the lack of it by others than ourselves. The shortsightedness thus so chronically deprecated really does not usually warrant either regret or reproach. We fail to see something far ahead just because it is not yet visible to us. Thus in the building of cities how much of destroying and rebuilding has to be done because of the shortsightedness of the original planners, and yet we must believe that they looked ahead to see as far as they could and successively did their best.

In this issue we speak of the completion and the putting into regular service of a portion of one of the new systems of tunnels and subways of Greater New York, to be used entirely for the local transportation of its citizens and near neighbors who do business, or who have their various interests to prosecute, within its borders. This tunnel system is only one of many works of similar character now being, or soon to be completed, and at once to be appropriated by the people and to be constantly relied upon as conveniences or necessities in the routine of their daily lives. If ever there was a call for foresight it surely must be now, to recognize and to prepare for the results of the new and permanent additions to our popular facilities of communication.

And yet who can tell what will be the new perplexities which will develop from our present mitigation of those which have been so long familiar? All these transportation facilities are designed first of all to relieve the congestion of population. The residence area of the city now so crowded, is to be indefinitely extended according to our growing needs so that all may have room to live and move in comfort and have good air to breathe.

That is good so far as it goes, and as far as we can see; but what if we are replacing—as we are—congestion by congestion? The new congestion of the business, or, rather, the office section of the city may not be as bad as the residence congestion, but still it develops its problems. The overcrowding of the office section of the city may not as yet be recognized, but the process which is distinctly leading towards it cannot long be ignored. The facilities of transportation encourage the multiplication of the tall office buildings, and these develop continually the need of increased transportation facilities, each perhaps approximately keeping pace with the other, so that at the present outlook upon this phase of it no one is seriously worrying.

But with all the rushing and crowding and the means continually developing to make more of the same, the only ultimate result, nothing has been done, nothing apparently is being planned to be done to provide increased street area. The streets of down town New York were planned for perhaps one per cent. of the throngs of people and the merchandise and supplies which now have to traverse them, and it will not take long to double the traffic while the streets spread no wider. An alarmist might easily suggest great possibilities of danger which we need not particularize. Some sudden alarm of sufficient magnitude could precipitate a wild stampede in which lives by the hundred might be trampled out. There are several narrow streets now in which in the hours of the business day all wheeled vehicles should be prohibited.

Additional street accommodation is the apparently most urgent need of the near future, merely for the human traffic, while freight and supplies are also to be provided for, and this can only be found underground. At present additional subways coincident with the lines of the streets are the temporizing solution, not to be seriously objected to as far as they can afford relief; but it will be well to begin to consider the construction of deep sunk solid rock tunnels interfering with nothing in their construction and making short cuts in various necessary, directions. These, of course, would necessitate a vast increase of elevator service, and there is no reason why the elevator might not be used for depths approximating the heights which it now commands.

THE REACH OF THE ROCK DRILL

The rock drill was originally devised for the specific purpose of perforating rock, usually for the insertion of explosives, and it would seem that its originators had never a thought of its employment for any other purpose than that of making holes in hard and brittle material. It was far enough from perfect in the beginning and many ingenious ones successively contributed to its improvement and to the securing of the high efficiency ultimately attained.

As happens to men so does it happen also to their instruments and agents. The achieving of valuable results leads invariably to the extension of the field of employment, and the doer of one thing well is before long promoted to the doing of many things often quite different from the first employment. First of all, the rock drill covered all the original requirements of rock drilling, being made in all sizes and with various peculiarities of detail to suit the different kinds of rock and the different conditions of working. Then besides the drilling of round holes in rock in any position and of any size and depth, and often under water for the deepening of navigable channels, it became a channeling machine in quite a different sense. It was arranged to cut channels or thin grooves in rock, and thus provided the working idea, and the means of carrying it out, for an entirely new and in fact a revolutionary system of stone quarrying.

The advantage thus secured and the economy of material and of labor permanently established by the modern system of stone quarrying are not sufficiently known or appreciated. We no longer attack a bed of rock in a careless and haphazard fashion, putting in holes without the semblance of system and then with heavy charges of evplosives knocking out shapeless chunks of rock of all conceivable sizes, some of them to be then laboriously shaped to whatever dimensions they may happen to come to, many to be entirely discarded and also vast quantities of material cut away in the shaping of those which could be made available. We now work carefully to dimensions in the act of quarrying. Usually there is a level or a vertical face to work to and then the piece to be produced is laid out and is cut to the size and shape required right in its native bed with little material wasted in the finishing, and the rock is in perfect shape and condition for other cuttings to follow.

Then there is the line of percussion coal-cutting machines, another adaptation and another extension of the employment of the rock drill. These also are of the channeling rather than the boring type, and they are making their own way, so that the proportion of machine-mined coal is constantly on the increase and production is cheapened.

The sheathing pile driver, another direct development of the rock drill, is in a way the simplest adaptation of the percussion principle. It applies force without the intervention of tools. It takes the place of the sledge and the man. It saves only labor, but nowhere, perhaps, has any device a chance to save in such a wholesale fashion. It will shower blows upon the end of a pile with such force and rapidity that it will do in a minute as much as a man would do in an hour, and never stops to rest. It thus by its facility makes a way for itself as few devices have had the opportunity to do, and it is sure of its job with the modern engineer.

And now we come around to a curious development, in that through the pneumatic tool the rock drill comes around to its original employment again. The so-called "hammer drill" which is now in highest favor with miners for "stoping work" is purely and simply a "pneumatic tool," the drill bit being forced constantly against the rock instead of reciprocating as in the "rock drill."

CORRESPONDENCE

The following comes to us from London:

Editor Compressed Air:

Possibly the following may amuse you, as it certainly did the writer. Happening some little time back into the Machinery Exhibition then being held at Olympia in this city, the writer noticed a rather extraordinary-looking rock drill, and stopped to ask the man in charge—who spoke with a broad Nottingham accent which an American typewriter can hardly be expected to reproduce—for some particulars.

"This 'ere is the Blankshire petrol drill, laad."

"Blankshire drill, is it? And what does the Blankshire drill do?"

"Ah'll tell thee what it's *a-goin'* to do, laad; it's a-goin' to knock out arl other drills on th' market, that's what it's a-goin' to do."

"And how it it going to do that?"

"'Cos it 'its 'arder and 'eavier than any on 'em, and runs cheaper."

"Sold any of them yet?"

"No, laad, there ain't been none of 'em sold yet; but that don't matter. It's the comin' drill, this is. Arl the others is a-goin'—Hingersolls and Rands and arl, arl of them's a-goin', and this 'ere drill is a-comin'. Compressed hair's a-goin' too—what's the good of buying a . . . hair-compressor when you can run a drill on petrol?"

"Bad news for the Compressed-air people, isn't it?"

"Can't 'lp their . . . troubles, laad; they're a-goin', they are."

"Well, I'd like to see your drill working; can't you start her up?"

"Ah'm sorry, laad, but Ah can't run her in 'ere—there's a lot of these 'ere people would be objecting to the smell of her, and the fumes of the petrol, and what not."

"Hum—then perhaps there's some hope for the compressed-air people after all. How are you going to manage about the fumes, and what not, when you get her running underground?"

At this point the demonstrator dropped his voice into a hoarse roar that was evidently meant to be a confidential whisper, and said, "Look 'ere, my laad; seems you know summat abaht these 'ere things, and Ah'll tell 'ee summat—this 'ere bloody drill ain't *meant* for underground!"

So that even when the Blankshire drill is perfected—if it ever is—there will still be some little field for compressed air.

A. B.

FLOW OF AIR IN PIPES

Editor of Compressed Air:

Mr. John J. Smith, in the August number of Compressed Air, criticised the formula for the flow of air in long tubes, which appeared in an article by me in the April number of your magazine, as "somewhat long and complicated." He quotes a formula by J. E. Johnson, Jr., published in the American Machinist, in July, 1899, which he considers simple. It is as follows:

$$P^2_1 - P^2_2 = \frac{KV^2_1 l}{d^5}$$

I will show that this is only a special case of the fundamental formula for the flow of air in long pipes, first developed by Prof. Unwin as early as 1875. Referring to my article in Compressed Air, for April, 1907, p. 4411, the fundamental formula is as follows:

$$u^1 = \sqrt{427.86 \frac{T\ d}{f\ L} \frac{p^2_1 - p^2_2}{p^2_1}} \qquad (1)$$

in which u^1=Initial velocity in feet per second,
L=Length of pipe in feet,
T=Absolute temperature of the air in degrees Fahrenheit,
d=Diameter of the pipe in feet,
$p1$=Initial absolute pressure,
$p2$=Final absolute pressure,
=Coefficient of friction.

Transforming this equation.

$$p^2_1 - p^2_2 = \frac{u^2_1\ f\ L}{427.86 Td}$$

which may be written

$$p^2_1 - p^2_2 = \left|\frac{f\ c}{427.86\ T}\right| \left|\frac{p^2_1 u^2_1 d^4}{c}\right| \frac{L}{d^5} \qquad (3)$$

If the coefficient of friction be considered constant—which it is not, for all experiments of sufficient range and accuracy show that it varies with the diameter of the pipe, and probably varies with the velocity of the air—and if the temperature of the air be also considered constant—although we know that it may vary twenty per cent. or more—then

$$\frac{f\ c}{427.86\ T}$$

is constant and may be written=K.

If the volume of free air flowing per second be V, then

$$V = \frac{u_1\ n\ d^2}{4} \times \frac{p_1}{14.7}$$

$$= \frac{p_1\ u_1\ d^2}{\sqrt{c}}$$

and

$$V^2 = \frac{p^2_1\ u^2_1\ d^4}{c}$$

This value of V^2 is the second factor in equation (3).

Substituting we have

$$p^2_1 - p^2_2 = \frac{KV^2L}{d^5} \qquad (4)$$

which is the formula quoted by Mr. Smith. So long as K is treated as a constant, this formula can only be correct for one temperature, one size of pipe, and probably one air velocity.

Furthermore, this is not a convenient formula for most cases in ordinary practice, simple as it may seem at first sight. What we usually want to know is the loss of pressure due to friction of the pipe, or $P1—P2$. This formula gives the difference of the squares of the pressures. If we solve it for $P1—P2$, it does not appear so simple, thus:

$$P^2_1 - P^2_2 = \frac{KV^2L}{d^5}$$

$$P_2 = \sqrt{P^2_1 - \frac{KV^2L}{d^5}}$$

$$P_1 - P_3 = P_1 - \sqrt{P^2_1 - \frac{KV^2L}{d^5}}$$

A better formula is obtained by solving the fundamental equation (1) for $P1—P2$ as follows:

$$u_1 = \sqrt{427.86 \frac{T\ d}{f\ L} \frac{p^2_1 - p^2_2}{p^2_1}}$$

transforming

$$\frac{p^2_1 - p^2_2}{p^2_1} = \frac{u^2_1\ f\ L}{427.86\ Td}$$

$$p_2 = p_1 \sqrt{1 - \frac{u^2_1\ f\ L}{427.86\ Td}}$$

$$p_1 - p_2 = p_1 \left| 1 - \sqrt{1 - \frac{u^2_1\ f\ L}{427.86\ Td}} \right| \qquad (6)$$

This formula gives the loss of pressure directly, and takes into consideration the temperature of the air. The value of the coefficient can be found for any size pipe by Prof. Unwin's formula

$$f = .0027 \left| 1 + \frac{3}{10\ d} \right| \qquad (7)$$

made by numerous experimenters under a great variety of conditions to be quite accurate.

In conclusion, we fail to see the "extreme simplicity of the formula" quoted, and the credit of being the first to develop a correct and rational formula does not belong to Prof. Church, nor to Mr. Johnson, but to Prof. Unwin, as I pointed out in a former communication.

B. C. BATCHELLER.

[The following letter was received recently. For obvious reasons the name and address of the writer cannot at present be revealed.]

Editor Compressed Air:

I have recently gotten up a new invention, a self compressing air engine. I claim to have discovered a way by which air can be compressed for all power purposes without the aid of any other engine or the use of any coal. I have made drawings of my invention which will plainly show its outlines and the plan of its construction, so as to prove what I claim for it.

QUESTIONS AND ANSWERS

I. W. W., Queensville, Ont. *Q.*: Will you kindly tell me if there is a machine made which will convey the exhaust air from an air motor back into the tank from which the compressed air issues that actuates the motor? *A.*: There is no machine in existence which recompresses and returns the exhaust air to the receiver. Some perpetual motion cranks have suggested such a scheme, but it of course has come to nothing. It would be found that before the air was returned to the receiver at its former pressure more than one half of the original power would be lost, even if the motor did no other motoring.

NEW BOOKS

Hydraulic Engineering, by Gardner D. Hiscox, New York, The Norman W. Henley Publishing Company. 315 pages 6 x 9 inches, 300 illustrations and 36 tables. Price $4.00. This handsomely printed book is not a work of original research nor an exhaustive treatise upon hydraulics and engineering, but is really broader in its reach, as better indicated by its sub-title, it being " a treatise on the properties, power and resources of water for all purposes." It is a compilation of various information upon the general topic, much of it from sources not generally available. Two of the most important chapters in the book have to do with the Air-Lift and the Hydraulic Air Compressor.

TRADE PUBLICATIONS

Small Power Driven Air Compressors. Form E 36, Ingersoll Rand Company, New York, 48 pages 6 by 9 inches. This beautifully printed and illustrated catalog treats of an important and widely serviceable line of air compressors built by the company. Both horizontal and vertical machines are shown, the free air capacities covering from 500 cubic feet per minute down to 8 feet or less, while the pressures range from the lowest up to the highest ever practically employed. The drive may be either by belt, chain or gear, a constantly growing practice being the use of an electric motor mounted upon the machine base.

Sheet Pile Drivers, Form 478 Ingersoll Rand Company, New York, 12 pages 6 by 9 inches. Perhaps no other developement of the percussion rock drill is finding its field of employment so rapidly and so widely extending as the apparatus here discribed. The sheet pile driver is becoming one of the most important adjuncts of the modern engineer. It comes in for trench excavation, in sinking cofferdams, shaft sinking, building tunnel approaches, retaining walls, in canal work, in dam construction or wherever soft or moveable material is to be fastened either permanently or pending other operations. The pamphlet is full of information and suggestion.

ARTIFICIAL ICE

There are purists who object to the above as applied to real ice produced by artificial means. It happens to be the most convenient and we think also the most obvious designation, and it also has full dictionary warrant. We quote from the Standard Dictionary its first and principal definition of "artificial," as follows:

"Artificial, *a.* 1. Produced or composed by art rather than by nature, but of the same materials, and with the same or nearly the same result; manufactured: distinguished from *imitation;* as, *artificial* rubies (real rubies produced chemically); *artificial* ice."

The following quotation is given by the dictionary in illustration:

"The invention of *artificial* light has extended the available term of life. Draper Intell. Devel. Europe."

To give way to the unwarranted demands of the finical in language usage is to add to our cowardice and to their conceit, neither of which results is much to be desired.

WESTINGHOUSE ALL RIGHT

I have much pleasure in being able to notify the clients and other friends of The Westinghouse Machine Company that the receivers appointed October 23, 1907, by the Circuit Court of the United States for the western district of Pennsylvania, were on March 31, 1908, discharged by the same authority. All of the matters which made a temporary receivership expedient have been satisfactory arranged, and the Company's position is greatly strengthened from every standpoint.

All contracts made by the receivers for the sale of the Company's products, or for the purchase of materials or merchandise will be carried out as though made by the Company's own officers.

I take this occasion to announce the election of Mr. William H. Donner as the Vice President of the Company in direct responsible charge of all of its activities, and to give the assurance of the continuance and accentuation under Mr. Donner's administration of that steadfast policy whereby the clients of The Westinghouse Machine Company have become friends as well as customers.

GEO. WESTINGHOUSE,
President.

COMPRESSED AIR IN COAL WASHING

A coal washing plant consists, primarily, of a great tank full of water. Into the top of this tank is dumped powdered coal from the culm heaps. Mixed with the coal are large quantities of comminuted slate and other impurities, the presence of which makes the culm useless as fuel. While the coal itself is slightly heavier than water all the impurities are, fortunately, still heavier. On this fact is based the practical working of the washing tank. Left to itself the whole mass of powder would sink to the bottom of the tank, the particles of coal sinking considerably slower than the adulterants. At this point the trained scientific knowledge of the German inventor took command. From the bottom of the tank he discharged upward into the water small currents of compressed air of just sufficient strength to overcome the slight tendency of the coal particles to sink. So the coal is kept on the top, while the heavier bits of slate and other impurities still sink slowly down to the bottom. And a constant stream of water flowing across the top of the tank carries off into hoppers practically all the available fuel in the form of almost pure carbon.—*Saturday Evening Post.*

AUTHORS HAVE THEIR TROUBLES

In announcing the appearance of Vol. VII. of the annual "Cooper Handbook" Horace J. Stevens of Houghton, Michigan, says, with becoming frankness: "I deem it but fair to advise you that the revision of the book from Vol. VI. has not been complete. Owing to an unfortunate train of mishaps, including fire, Pasteur treatment on account of the bite of a rabid cat, blood-poison, three surgical operations and a number of minor mishaps, not helped by the panic and several printer's strikes, so much time was lost that it was impossible for me to revise the detailed mine descriptions in Chapter XV. of Vol. VI. Everything else, however, has been revised most thoroughly." Concluding his circular, Mr. Stevens says: "I am sorry to send out a book not entirely revised, but the loss of five month's time, about $20,000 in cash and a square foot of skin interfered with my previous plans."

TRANSPORTATIONOF LIQUID AIR

Liquid air has become in Europe a recognized article of merchandise, and a recent international convention to fix the conditions of transportation of various forms of merchandise has admitted liquid air as railway freight subject to the following conditions:

Liquid air is admitted as freight when contained in bottles, surrounded with felt and closed with a felt stopper allowing escape of the gas without producing high pressure in the interior or letting the liquid run out. This felt stopper must be so fixed that the bottle will not be emptied if it upsets. Each bottle, or several bottles together, must be protected against shocks by a crate of iron wire or some other similar recipient. These crates must be carried either in metal chests open at the top or protected by a grated or perforated cover, or in wooden cases marked "liquid air," "top," "bottom," "very fragile." These receptacles should contain no easily inflammable packing, such as sawdust, excelsior, peat, straw, or bran. Chests or cases must be quite tight below, up to a height so great that, in case of breakage of the bottles, no liquid can run out. The cases must be placed in the cars in such a manner that they can not fall or be upset, and so that the bottles stand upright and can not be injured by other freight. No substance easily inflammable in small pieces or in the liquid state may be packed in the immediate neighborhood of the liquid air. Instead of glass double-walled bottles, covered with felt, other recipients may be employed, always on condition that they be so protected that they can become coated neither with dew nor with frost. If these receptacles are strong enough and can stand upright, they need not be surrounded by wire crates or be protected in any other way.—Translation made for *The Literary Digest.*

$25,000 PRIZES FOR A ROCK DRILL CONTEST

The recent rock drill contest conducted by *South African Mines,* and the continuing demand for better rock drill efficiencies and conveniences, has stimulated the Transvaal Government, in connection with the Johannesburg Chamber of Mines to announce another contest, allowing about a year for preparation, for the best practical small rock drill. Two prizes are to be offered, one of £4,000 and one of £1,000, the conditions of the contest and all details to be settled by a committee of engineers nominated jointly by the Government and the Chamber. Not less than £250 additional will be available for the men who operate the drills. It is understood that the trials will be severe and protracted, but as near actual working conditions as possible.

Vacuum cleaning for household use has been rapidly on the increase in the past year or two. One can now find on the market electric motor driven apparatus all the way from a light portable apparatus weighing only 70 lb., using a one-sixth horse-power motor and costing about $125, up to large stationary plants employing motors from 5 horse-power up, and costing many hundreds of dollars. The machines range all the way from those producing a very small vacuum and moving a considerable volume of air up to others maintaining 15 in. vacuum, which will pull the dust clear through an ordinary rug.

SPRING MEETING OF THE MECHANICAL ENGINEERS

The Semi-Annual Meeting of The American Society of Mechanical Engineers will be held in Detroit, Michigan, June 23-26. Among the papers to be presented at this session are "A Method of Cleaning Gas Conduits," by W. D. Mount; "A Method of Checking Conical Pistons for Stress," by Prof. George H. Shepard; "Clutches" with special reference to automobile clutches, by H. Souther; "Horse-Power, Friction Losses, and Efficiencies of Gas and Oil Engines," by Prof. L. S. Marks; "Some Pitot Tube Studies," by Prof. W. D. Gregory; "The Thermal Properties of Superheated Steam," by Prof. R. C. H. Heck; "A Journal Friction Measuring Machine," by Henry Hess; "A By-Product Coke Oven," by W. H. Blauvelt; "Tests of Some High Speed Steam Engines," by F. W. Dean. There will be a symposium upon machinery for conveying materials, with papers by several authorities. The Society for the Promotion of Engineering Education and the Society of Automobile Engineers will also hold their annual meeting in Detroit at this time, which will enable members of each Society to participate in the sessions of the other.
NOTES.

AIR LIFT WITH ELECTRIC MOTOR

The air lift has never had any great claims for economy made for it, but it certainly eliminates much of the uncertainty of service and expense of repairs to apparatus which operates deep in a well, because all of the moving machinery is entirely outside of the well. Assuming that a central station company is able to do all of its pumping from a well at times when it has ample engine and generator capacity, the question of the inefficiency of the air lift in a small central station need not cause much concern. If the air compressor is operated either by a belt from an engine used to drive a generator, or by a motor from the generator, it will usually cause a surprisingly small increase in the coal consumption. The reason for this is that many of the fixed losses in the engine and boiler plant are so large on light loads that a small addition to the load does not make a proportionate increase in the coal bill.

* * * * *

In a small plant, where it is desirable to keep the investment down, the air compressor, which can so easily be adapted either to motor or engine drive, has strong claims for recognition.—*Electrical World.*

FOR RAISING SUNKEN OR STRANDED SHIPS

A new system employing compressed air for raising sunken ships is named the Fearon. The method by which the air vessels are fixed to a ship is its most striking feature. To begin operations two or three air vessels are fixed to the forward portion of the submerged boat, and when these are inflated that end rises so that divers can begin operations. They fix a tackle, consisting of wire rope, rings, etc., which covers the sides of the ship with a network to which air vessels can then be attached. These are then inflated and the ship rises. This system is only applicable where a diver can work. The air vessels are made of canvas and india-rubber or "diver's" cloth." By this arrangement a vessel may be provided with a complete air belt of any required capacity.

A CLYDE SHIPBUIDER ON PNEUMATIC TOOLS

Mr. John Ward, president of the Scottish Institution of Engineers and Shipbuilders, in a recent address said that in the open market for new ships the most dreadful competition that had ever been seen had taken place within the last year or eighteen month, and was still going on. Shipbuilders openly acknowledged that, so far from profit being an object, it had disappeared into the background, and that now they looked upon it as a necessity to keep their places going at any cost. And while this was so at home, Germany and America were rapidly pulling up on them, and had produced some fine work during the past year. In the latter country, which he had visited, pneumatic tools for calking, cutting and riveting were in general use, and the results of their adoption were the lessening of the heavy manual labor and substantial increases of the workmen's earnings, together with improved workmanship. On this side of the Atlantic they had had experience of the calking and cutting tools; but, from some inexplicable reason, a dead-set had been made against them by the men for riveting. He was certain were they given an honest trial there would be a great advantage.

NOTES

The new British turbine torpedo boat destroyer Tartar on her recent trial attained a speed of 35.92 knots per hour—41.39 miles.

Lester A. Pelton, inventor of the Pelton waterwheel, died at Oakland, California, March 15th, 78 years old. Mr. Pelton was born in Ohio and went to California in the rush of '49. His wheel was first used in gold mining operations in California, and its name has become typical of impulse wheels in general, especially those using great pressures.

"High pressure air pipe lines, though smaller in diameter, require more care to keep them tight than lines for low pressure." A little more care may be required when connecting pipes for high pressure to make sure that they are tight, but practically no care is ordinarily required to *keep* them tight. If leaks exist, however, they may be expected always to enlarge, the process continuing without limit.

The old Port Royal mine of the Pittsburg Coal Co. is to be emptied of the water that has filled it for years. Three ten-inch holes are being drilled from the surface to the interior of the mine, a distance of 365 feet, and in each will be placed a six-inch discharge pipe. Each of these discharge pipes will be capable of discharging 2,000,000 gallons of water per day by the air lift process, all of which will be emptied into the Youghiogheny river. When the drill penetrated the old workings, the pressure of the gas threw the water as high as the derrick.

Karl Lanz, a merchant of Mannheim, has handed over to the German Aeroplane Club $10,000 to found a prize to be contested for by aeroplanes heavier than air. The aeroplanes must be constructed by German builders in Germany, and be propelled by home-made motors. The competition will be held over the Tempelhof parade ground. Herr Lanz has given also $2,500 to help poor German aeroplane inventors.

In order to ascertain what really takes place when coal is submitted to a moderate rise of temperature with limited access of air in closed vessels, Dr. Habermann some time ago carried out a series of experiments at Munich with different kinds of coal, which were broken up into small fragments about the size of peas, and kept for eight days in iron retorts heated to a temperature of 142 degs. Cent. (287 F.); two 1¼ air pipes were inserted near the bottom of the retort, but there was no other opening. Some kinds of coal heated rapidly and ultimately reached a temperature of 350 degs. Cent. (662 F.), but with other descriptions of coal the rise in temperature was less marked.

Gas in a tunnel of the Pennsylvania Railroad under the City of Baltimore, in March, caused the death of four workmen by suffocation and rendered unconscious a score of others who revived. The tunnel is the most northerly one of those carrying the allied Pennsylvania lines under the city. It is more than half a mile long, for two track travel, being 27 feet wide and 22 feet above the rail. There was a 15 foot electric driven ventilating fan near the middle of the tunnel, but two or three days before the accident this fan was stopped for repairs. When the men were sent in to perform necessary tunnel work the gas had accumulated to such an extent that the men were overcome as above stated.

The famous Iron Mountain tunnel has recently been completed, and the unwatering of the old Iron Mountain mine in western Montana by means of drainage through the tunnel has begun. The mine shaft had filled with water to a depth of 900 feet above the point where it was tapped by the tunnel. The tunnel will take care of the water by the natural gravity system above the 1,700-foot level of the mine and below that level it will be pumped to the tunnel and allowed to flow out. The completion of the enterprise will effect a great saving to the company in the operation of the mine. The distance from the mouth of the tunnel to where it intersects the shaft is 5,560 feet, or more than a mile. The work was begun March 21, 1906. After the mine is unwatered mining operations upon an extensive scale will be commenced.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

MARCH 3.

880,570. COMPRESSED-AIR LIQUID-ELEVATOR. John H. Phillips, Pottsville, Pa.

880,595. PNEUMATIC-DESPATCH-TUBE APPARATUS. Charles F. Stoddard, Boston, Mass.

880,607. PNEUMATIC MOTOR FOR ADDING MACHINES. Charles Wales, Detroit, Mich.

880,698. ACETYLENE-GAS GENERATOR. Harvey S. Stoner and Burton Stoner, Massillon, Ohio.

880,731. AIR-COMPRESSOR. George F. Hall, Jersey City, and Benjamin Albertson, Mantoloking, N. J.

880,746. AIR-PUMP. Joseph B. Meriam, Cleveland, Ohio.

880,763. ACETYLENE-GAS GENERATOR. Harvey S. Stoner and Burton Stoner, Massillon, Ohio.

880,815. STORED - PRESSURE MOTOR-STARTING DEVICE. Edward P. Noyes, Winchester, Mass.

880,824. VALVE MECHANISM FOR ENGINES AND COMPRESSOR. Sidney A. Reeve, Worcester, Mass.

880,881. PNEUMATIC AND OTHER DRILL. Martin Hardsocg, Ottumwa, Iowa.

1. A shank for a pneumatic tool, formed of a base, a curved wing extending from each side edge of the base on one face thereof, with the abutting ends of the curved wings in contact and forming, with the base, a passage longitudinally of the shank, a central rib on the base, and a curved wing on each side of the center of the base, with the abutting edges of the wings in contact and forming, with the base, a passage, each passage extending longitudinally of the shank and one passage furnishing a means for admitting a cooling medium to the cutting end of the tool, and the other passage furnishing a means for withdrawing dust and fine particles from around the cutting end of the tool, substantially as described.

881,040. COMPRESSOR FOR INTERNAL-COMBUSTION ENGINES. Harry W. Adams, Fargo, N. D.

881,059. ROCK-DRILL. Henry J. Cook, Ottumwa, Iowa.

1. In a rock-drill, a casing having a tubular drill stem mounted at one end, an air-propelled hammer, a striking-head mounted between the hammer and the drill-stem having a hole therein that registers with the hole in the drill-stem, and a hose connection secured to said striking-head and communicating with the hole therein, substantially as shown and described.

MARCH 10.

881,116. AIR OR VACUUM PUMP. Wills M. Fleming, Holyoke, Mass.

881,176. APPARATUS FOR THE LIQUEFACATION OF AIR. Georges Claude, Paris, France.

881,195. SIGHT-GLASS AND SEPARATOR FOR PNEUMATIC RENOVATORS. William F. Moughler, Toledo, Ohio.

881,327. AIR-SHIP. John W. Montgomery, Columbus, Ohio.

881,351. VACUUM-PAN. Alonzo P. Smith, Philadelphia, Pa.

881,431. APPARATUS FOR CARBURETING AIR. Charles L. Meyer and Nicholas P. Hickey, Detroit, Mich.

881,498. AIR-COMPRESSOR. John Sturgess, Troy, N. Y.

881,516. ANNULAR VALVE FOR COMPRESSORS, BLOWING-ENGINES, AND THE LIKE. Jean A. Willaredt, Brussels, Belgium.

881,548. AIR-EXHAUSTING LIQUID-SUPPLY APPARATUS. Charles A. Claflin, Medford, Mass.

881,836. WING FOR FLYING-MACHINES. Everett E. Warner, Hartford, Conn.

881,837. AEROPLANE. Gustave Whitehead, Bridgeport, Conn.

881,885. AIR MOTOR. Lewis B. Doman, Elbridge, N. Y.

MARCH 17.

882,085. FLUID-PRESSURE GENERATOR. Marion Warren, Rochester, N. Y.

882,189. FLYING-MACHINE. Edwin L. Drake, Winchester, Tenn.

882,215. TIRE-PUMP. William S. Stapley, Bridgeport, Conn.

882,219. VENTILATING SYSTEM FOR ROOMS AND THE LIKE. Sergius Timochowitsch, Moscow, Russia.

1. In a ventilating system for rooms and the like, the combination of a chamber located directly beneath the ceiling of the room and having its under side closed by a filtering medium, air supply ways connecting said chamber with the outer air, air exhaust ways separated from said chamber and leading from the top of the room to connect the room with the outer air, and fans in said supply ways and exhaust ways.

882,259. PNEUMATIC CARVING-DRILL. Herman Meyer, St. Louis, Mo.

882,312. APPARATUS FOR FACILITATING THE PUTTING ON OF INDIA-RUBBER GLOVES. Carel A. Hoefftcke, London, England.

1. An apparatus for facilitating the application of India rubber gloves to the hands of the wearer, consisting of a chamber having an annular opening at the top sufficiently large for the insertion of the hand, an annular collar around said top opening over which the wrist of the glove is stretched, so that it depends into said chamber and forms a closure therefor, means for securing the wrist portion of the glove to said collar; and means for temporarily reducing the pressure of air in said chamber, whereby the glove is stretched to admit the wearers hand, substantially as set forth.

882,338. REGULATOR FOR COMPRESSORS. Fred E. Norton and Irving H. Reynolds, Youngstown, Ohio.

882,350. SEAL FOR PIPE-JOINTS. Bernard F. Shaughnessy, Pittsburg, Pa.

882,406. AUTOMATIC COUPLING FOR AIR-BRAKE SYSTEMS. Benjamin J. Morgan, Bevier, Mo.

882,435. FLYING - MACHINE. Thomas J. Whalen, Middlebrook, Va.

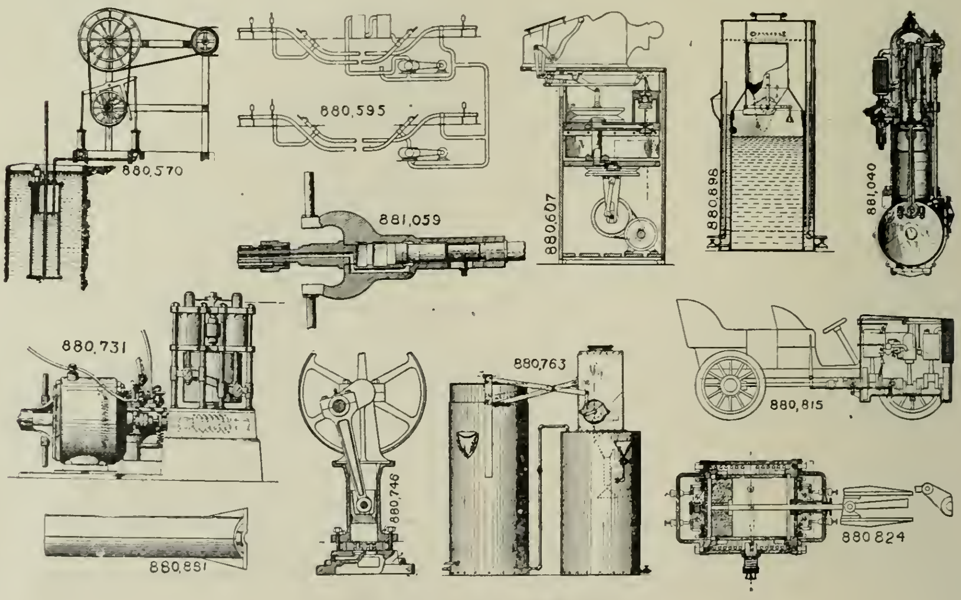
882,457. FLYING-MACHINE. Emil R. Ernst, Warrenpoint, N. J.

882,477. CENTRIFUGAL SUCTION-MACHINE. Christian Neumann, St. Louis, Mo.

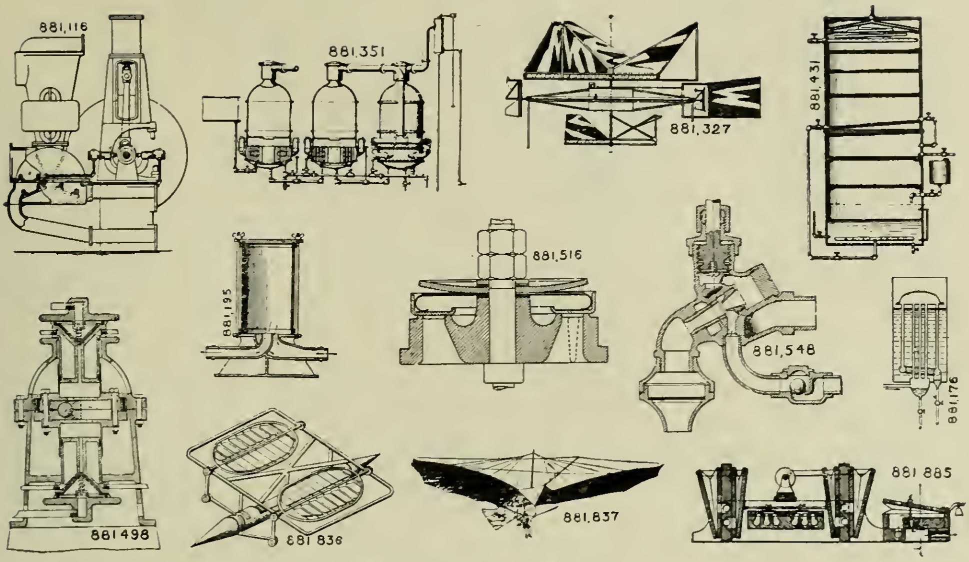
882,478. PRESSURE-BLOWER. Christian Neumann, St. Louis, Mo.

882,503. AIR-HOSE COUPLING. Walter W. Kilpatrick, Atlanta, Ga.

882,528. GAS-GENERATOR. Fred Mears.



Pneumatic Patents, March 3.



Pneumatic Patents, March 10.

Minneapolis, and Joseph Craig, Princeton, Minn.

1. In a generator for producing compounds of nitrogen and oxygen, the combination with a retort and a generating rod, of a holder for said rod, which holder is adjustably suspended within the retort and supports said rods with freedom for the gravity feed of the rod as it is consumed by the acid, substantially as described.

882,532. PNEUMATICALLY-OPERATED MASSAGE APPARATUS. Thomas A. McCall, Xenia, Ohio.

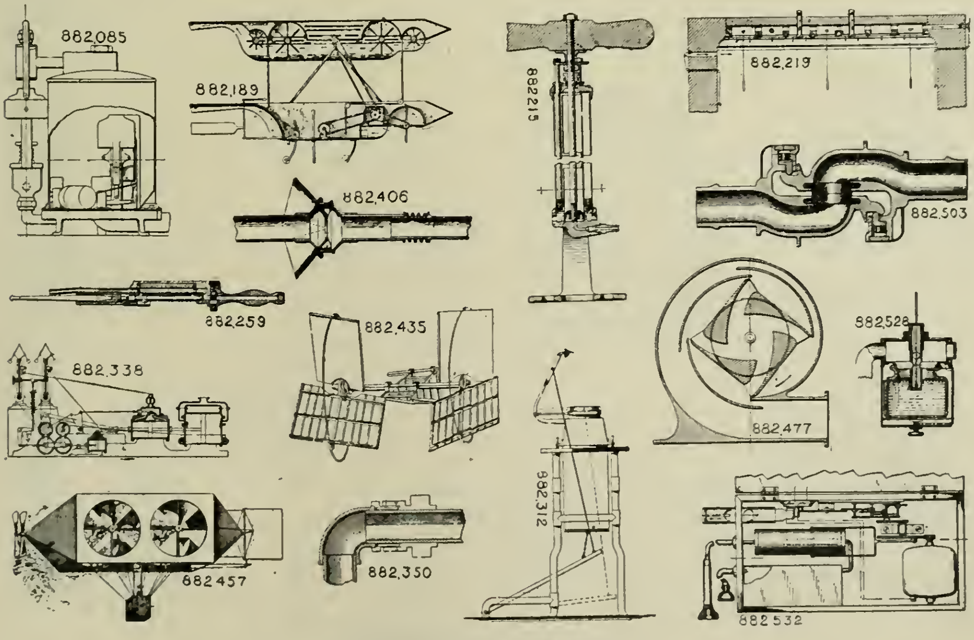
MARCH 24.

882,574. PNEUMATIC CLEANING-TOOL. Charles Moukos, Milwaukee, Wis.

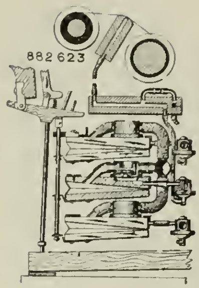
882,597. STARTING DEVICE FOR INTERNAL-COMBUSTION ENGINES. Frank H. Walker, Atwood, Kans.

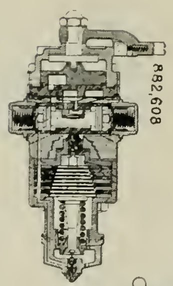
882,608. ENGINEER'S VALVE FOR AIR-BRAKES. Walter M. Austin, Swissvale, Pa.

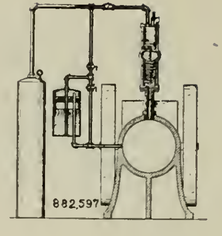
882,623. PNEUMATICALLY-OPERATED MUSICAL INSTRUMENT. Theodore P. Brown, Worcester, Mass.

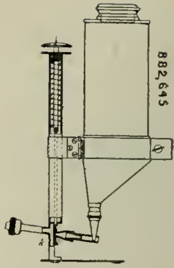


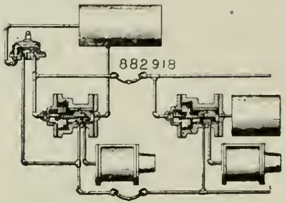
Pneumatic Patents, March 17.

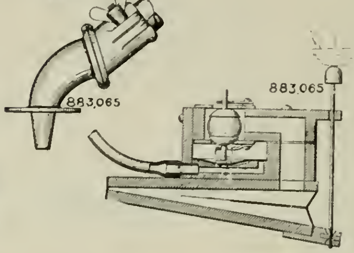


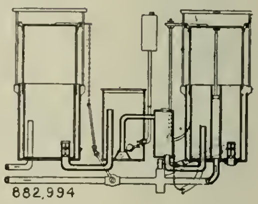












Pneumatic Patents, March 24.

882,645. HAND-OPERATED SAND-BLAST. Hans Mikorey, Schoneberg, near Berlin, Germany.

882,918. AIR-BRAKE. Walter V. Turner, Wilkinsburg, Pa.

882,994. AIR-FORCING MEANS FOR A GAS-GENERATOR. George P. Campbell and Frank H. Ringemann, Cincinnati, Ohio.

883,065. PNEUMATIC-VALVE MECHANISM. Theodore Vrana and Bretislav Schiba, New New York, N. Y.

MARCH 31.

883,292. PNUEMATIC GRAIN-CONVEYER. William F. Carlton, Advance, Mo.

883,316. BLOWING-ENGINE. Patrick H. Kane, Buffalo, N. Y.

883,347. COMPRESSOR. Edmund W. Roberts, Clyde, Ohio.

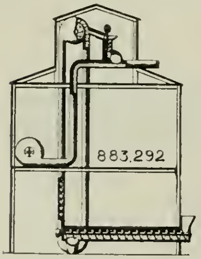
883,413. PNEUMATIC DUST-COLLECTOR. William F. Mahoney, Washington, D. C.

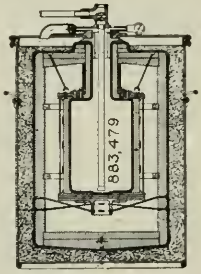
883,464. BLOWER. George W. Leiman and William H. Leiman, New York, N. Y.

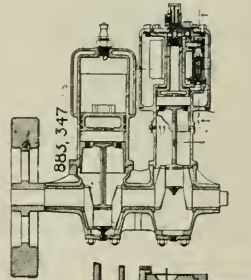
883,479. INSULATED CONTAINER FOR LIQUID AIR, &c. James F. Place, Glenridge, N. J.

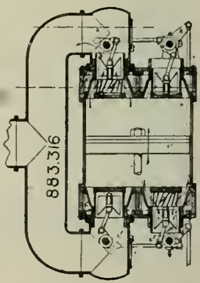
883,565. AERO-TUBE. Wiltje Pars, Seattle, Wash.

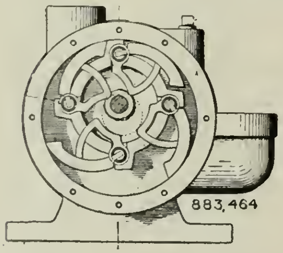
883,600. PNEUMATIC VALVE-ACTION. Joseph Wieser, New York, N. Y.

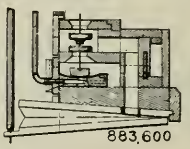


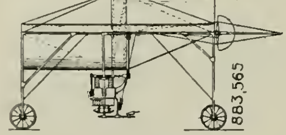


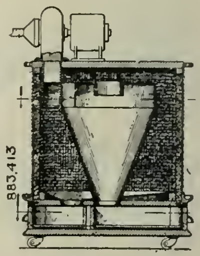












Pneumatic Patents, March 31.

COMPRESSED AIR
AND EVERYTHING PNEUMATIC.

Vol. XIII JUNE, 1908 No. 6

IMPERFECT INTERCOOLING AND EFFICIENCY OF COMPRESSION.

By S. B. Redfield.

As the public becomes more and more familiar with compressed air and the losses brought about by poor design and construction, prospective buyers of air compressors are becoming more and more interested in the subject of Intercooling. Most people know that the benefit of compound or stage compression depends upon the intercooling, and that the better the cooling effect the higher the economy, although it is probable that but few have ever taken the trouble to figure out what this actually amounts to. As those who give any thought to the mat.er usually specify an impossible degree of cooling, it goes to show that they have an exaggerated idea of the facts. In the belief that figures will be interesting and that the clearest way of presenting figures to the mind is by means of diagrams and curves, this problem has been worked out on this plan and the results obtained may serve to make the matter clear.

It can be mathematically proved that with multistage compression to a given pressure, the minimum work will be required when the work is equally divided between the several cylinders, and this occurs when the ratio of compression is alike for the several stages. In this article attention will be confined to compound, or two stage compression, as this is the most usual case.

The effect of poor intercooling is to raise the pressure in the intercooler, and thus to disturb the balance of power between the cylinders. As the intercooling becomes less and less effective, and the intercooler pressure becomes higher and higher, the work of the low pressure cylinder increases. Although at the same time the work of the high pressure cylinder decreases, this does not occur as rapidly as the increase in the work of the low pressure cylinder, and the net result is an increase in the total work done.

To examine the process in detail, turn to the theoretical adiabatic indicator cards, (Fig. 1). These cards are placed one above the other for comparison and lines are drawn through all to show the relative volumes of the high and low pressure cylinders, which are the same for all. The total ratio of compression from atmosphere to 100 lbs. at sea level is 7.8 and in order to make the work equal in both stages of the compound compression, and thus a minimum, the cylinder ratio is made the square root of the total raio, or 2.79. With perfect intercooling this gives the same ratio of compression in each cylinder, and, as before stated, requires the minimum work. In each diagram, the net theoretical saving by compounding is shown by the shaded area. This will be seen to grow less and less as the intercooling becomes less effective.

The upper card shows perfect intercooling, equal horse power in the two stages and minimum total horse power. Starting with 60 degrees. F., in each cylinder, the maximum temperature attained by compression in each stage is 240 degrees. The intercooling being perfect, the temperature of the inlet to the high pressure cylinder being the same as that to the low pressure cylinder, the pressure in the intercooler, or inlet to high pressure cylinder, is that corresponding to the isothermal curve, or 26.3 lbs. per square inch. This is of course obtained by multiplying the absolute intake pressure, 14.7, by the cylinder ratio, 2.79, giving 41 lb., absolute, or 26.3 lbs., gage. This gives 7.7 I. H. P. in each stage, or 15.4 total per 100 cu. ft. per minute.

Passing to the second theoretical indicator card, this shows the result when the intercooling fails to reach perfect conditions, by 150 degrees. In other words, the temperature of the inlet to the high pressure cylinder is now 210 degrees, instead of 60, which is an excess of 150 degrees. Under these conditions, the volume of the high pressure cylinder necessarily remaining constant, the intercooler pressure must rise, in order to take care of the air. The pressure will rise in direct proportion to the absolute temperature. This will be $41 \times \frac{210+461}{60+461} = 52.8$ lbs., absolute, or 38.1 lbs., gage, as shown.

The adiabatic compression line meets this new intercooler pressure line at a higher point than before, and the temperature corresponding to this point, or the maximum low pressure cylinder temperature, is now 292 degrees. This is an increase of 52 degrees above that obtained with perfect intercooling, which was shown to be 240 degrees.

Commencing to compress in the high pressure cylinder, at 38.1 lbs, pressure and 210 degrees, the final temperature attained with adiabatic compression to 100 lbs. is now 376 degrees as shown on the diagram. This is an increase of 136 degrees above that obtained with perfect intercooling.

Under these conditions, although the horse power in the high pressure cylinder has decreased to 7.21 from 7.7, the horse power of the low pressure cylinder has increased to 9.95, from the same figure. This gives a total of 17.16 I. H. P. per 100 cubic feet per minute, instead of 15.4, the figure for perfect intercooling. The diagram clearly shows the decrease in the shaded area, or the theoretical net saving by compounding.

From both these diagrams it will be seen that the line of adiabatic compression in the low pressure cylinder, if extended, would meet the line indicating the volume of the high pressure cylinder at a point corresponding to a temperature of 332 degrees. If there were no intercooling at all, the air would enter the high pressure clyinder at this temperature, and the pressure would have to be 47.7 lbs. gage. All this is shown in the third or lowest diagram, which represents the conditions resulting from no intercooling, or an excess of 272 degrees over perfect intercooling.

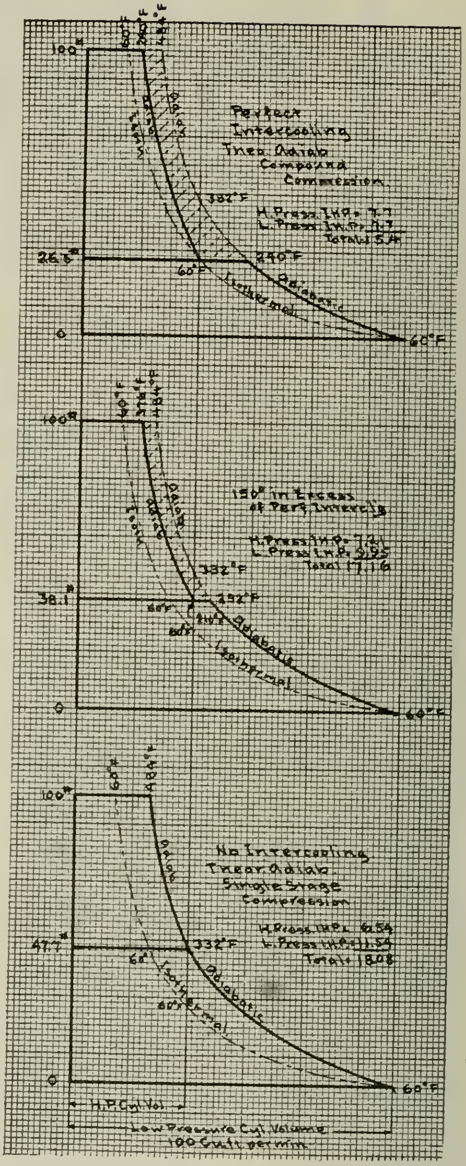


FIG. I—DIFFERENT RATES OF INTERCOOLING.

The compression line of the high pressure cylinder starts in where that of the low pressure cylinder left off, and the line is continuous. The result of this is a final compression temperature of 484 degrees at 100 lbs. pressure, and while the horse power in the high pressure cylinder has decreased to 6.54, that of the low pressure cylinder has again increased and is

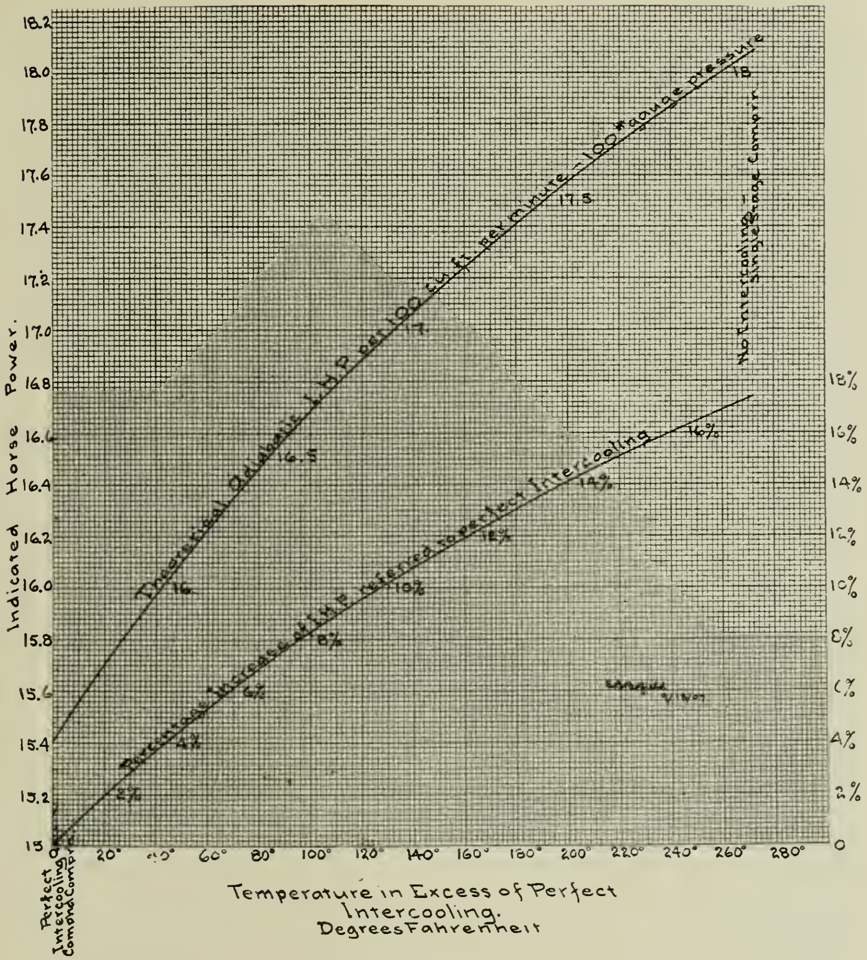


FIG. II.

now 11.54, making a total of 18.08 I. H. P. per 100 cubic feet per minute to 100 lbs. pressure. This is now nothing more than single stage adiabatic compression, and the theoretical horse power is that corresponding to single stage compression to 100 lbs. pressure. Here, the saving by compounding has of course entirely disappeared, and the work might as well have been done in one cylinder.

In order to show the result upon the power of progressive falling off in intercooling effect, two sets of curves are given in Fig. 2 showing the total theoretical adiabatic I. H. P. per 100 cubic feet per minute to 100 lbs. gage, and also the percentage increase in power, referred to perfect intercooling, as the intercooling becomes poorer. In this diagram the vertical distances represent I. H. P. for the one curve and percentages for the other, while the horizontal distances represent excess of temperature of high pressure cylinder intake, over that of perfect intercooling. Take, for example, the point marked 100 degrees; this means that the temperature of the air leaving the intercooler and entering the high pressure cylinder is 100 degrees in excess of perfect cooling, which would be 60 degrees, and it is therefore 160 degrees. At this point, the total indicated horse power per 100 cubic feet per minute to 100 lbs. gage is shown to be 16.69, and the increase over that for perfect intercooling is 8.3 per cent.

At the left of these curves is shown the result of compound compression with perfect intercooling, requiring 15.4 I. H. P. per 100 cubic feet per minute to 100 lbs. pressure and at the right hand end is shown the result of no intercooling at all, which is 272 degrees in excess of perfect intercooling, or, as was previously shown, theoretical adiabatic single stage compression. At this point the theoretical excess of power required over perfect conditions is 17.4 per cent.

Fig. 3 shows the variation in the horse power in each cylinder and the rise in intercooler pressure as the degree of intercooling falls off. The curves show at a glance the result of any partial degree of intercooling, and it will be seen that the increase of power required with 20 degrees excess of temperature is 2 per cent., and with 40 degrees excess it is 3.7 per cent. Of course, as the maximum theoretical increase of power due to no intercooling at all is 17.4 per cent., the first figure represents a loss of 2 in a possible 17.4, or 11.5 per cent. of maximum loss, and the second figure represents a loss of 3.7 in a possible 17.4 or 21.3 per cent. of the maximum theoretical loss.

When possessed of these figures the prospective compressor buyer will jump to the extreme and call loudly for "more cooler surface," and will insert into his specifications a clause calling for a degree of intercooling which the manufacturers know is practically impossible.

The word "practically" is full of import, for it is the practical results that mean dollars and cents, and it is the latter which interest the public. This being the case, and it having been repeatedly stated that these diagrams are theoretical, nothing would be more desirable than to interpret these theoretical figures into practical ones, and at the same time to show that while the public often demands impossibilities in one direction, other and important features, which are not only possible, but practical, and mean material saving, are never mentioned.

The particular subject meant by the above is what is known as "Efficiency of Compression" and it must be admitted that the term is seldom used by the buying public, either in conversation or in specifications. Nevertheless, this efficiency of compression is a most important subject, especially as, unlike the subject of intercooling, great improvements are possible and practicable by suitable design.

It is sometimes thought that adiabatic compression is the "worst that may be expected" and that figures for indicated horse power can never exceed the adiabatic. This is indeed a false idea, for the actual horse power as obtained by an indicator, for a given amount of air actually compressed and delivered, is always in excess of the adiabatic figure. This does not mean that the compression curve shown on the actual indicator card is above the adiabatic, for, if it is, it is imperative to look at the discharge valves at once to find, and stop, the enormous leak back into the cylinder that must be taking place. The curve of compression in a correctly operating compressor will be slightly below the adiabatic line, but owing to the "humps" in the discharge line, due to throttling through the discharge valves, the actual indicated horse power exceeds the theoretical figure, the latter not including "humps."

The "Efficiency of Compression," referred to adiabatic figures, is the ratio of the theoretical adiabatic I. H. P. per hundred cu. ft. per minute to the actual I. H. P. by the indicator card per hundred cu. ft. of free air actually compressed and delivered per minute, including volumetric efficiency.

As an example, suppose the piston displacement of a certain compressor were 108 cu. ft. per minute, and that the card showed 92½ per cent. volumetric efficiency, and that the actual I. H. P. by the card was 18, with 100 lbs. gage pressure, compound compression. This would mean that 92½ per cent. of 108, or 100 cu. ft. per minute, was actually compressed and delivered and that the actual I. H. P. developed in compressing this 100 cu. ft. of air was 18. The theoretical adiabatic I. H. P. per 100 cu. ft. per minute actually compressed and delivered by compound compression to 100 lbs. is 15.4. The efficiency of compression then is 15.4 divided by 18, or 85.5 per cent. This figure appears low, and it really is low compared to what some first class manufacturers are now doing. It is probable, however, that there are more compressors with 85.5 per cent. or less efficiency of compression than there are with higher; and yet the public never says a word about it, but devotes its attention to impossible degrees of intercooling, which call for absolutely uneconomical areas of cooling surface and rivers of cooling water.

This efficiency of compression, with ample valve and passage area, may come up to as high as 93 to 94 per cent. for compound com-

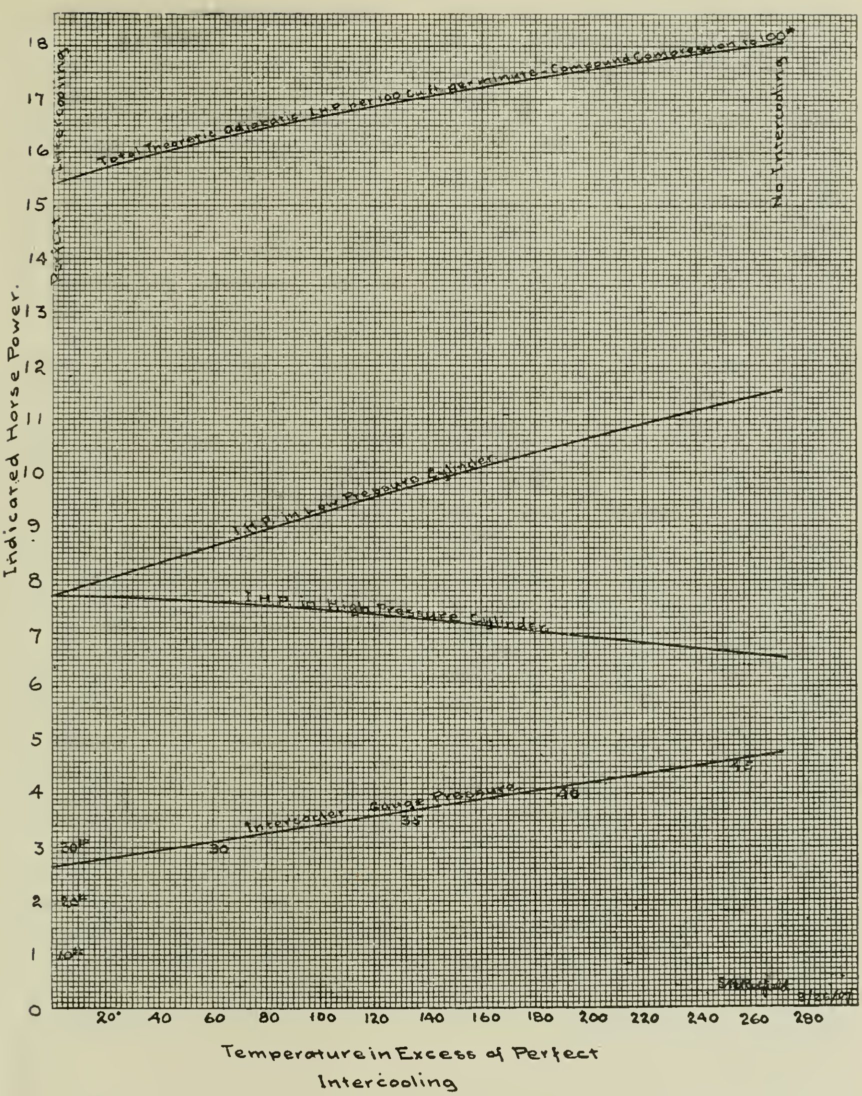


FIG. III

pression to 100 lbs. The losses involved are due to two main causes—defective intercooling and contracted valve and passage area. In order to separate these two causes of loss, assume a practical case, and as an average figure let the efficiency of compression be 90 per cent., and let the intercooling be within 40 degrees of perfect, both of which figures are fair assumptions. The latter figure means that the temperature of the air leaving the intercooler and entering the high pressure cylinder is 40 degrees higher than that entering the low pressure cylinder. Referring to the curves, this would mean an excess of I. H. P. of 3.7 per cent. over that obtained with perfect intercooling.

If the efficiency of compression is 90 per cent., the actual I. H. P. per 100 cu. ft. per minute must be 17.1 A glance at the curve for I. H. P. will show that 40 degrees excess temperature should require 15.97 I. H. P. per 100 cu. ft. This means that the difference between 15.4 and 15.97, or .57 horse power, has been lost from imperfect intercooling, and the rest, or the difference between 15.97 and 17.1, or 1.13 horse power, has been lost on account of insufficient valve area. To go to percentage: .57 is 3.7 per cent. of 15.4, as shown by the curve, and 1.13 is 7.34 per cent. of 15.4. As a fairer comparison would be the percentage referred to the actual horse power obtained, it is best to say .57 is 3.33 per cent. of 17.1 and 1.13 is 6.6 per cent. of 17.1. This shows that the loss by contracted valve area is in this case almost exactly twice as great as that due to poor intercooling.

As beforesaid, with first class practice, the efficiency of compression may be as high as 93 to 94 per cent. for compound compression to 100 lbs. Taking 94 per cent., the actual I. H. P. per hundred cu. ft. per minute to 100 lbs. will be 15.4 divided by .94, or 16.4, making a total loss of only one horse power, over and above the theoretical.

Again, assuming 40 degrees excess of temperature over perfect intercooling, the loss due to imperfect intercooling is again .57 horse power, which leaves the remainder, or .43 horse power, to be chargeable to throttling through valves and passages. .57 is 3.48 per cent. of 16.4, and .43 is 2.62 per cent. of 16.4, the actual power required. Now it is seen that with proper valve and passage areas, the loss due to throttling is even less than that due to poor intercooling.

What is more interesting still than this fact is, that the actual H. P. per hundred cu. ft. per minute has been reduced from 17.1, the figure with 90 per cent. efficiency of compression, to 16.4 with 94 per cent. This makes the net saving in power .70 I. H. P. per 100 cu. ft. per minute, which is over 20 per cent. more than .57 I. H. P., the total loss by inefficient cooling with 40 degrees excess of temperature, which latter is not the best a commercial intercooler can do.

From the foregoing arguments, it will be clear that although the buying public should not forget the subject of intercooling, as this is a very important item, it would be highly advisable to put it into its proper relative position and to look more carefully into the equally important, but often overlooked, subject of valve and passage area and the efficiency of compression.

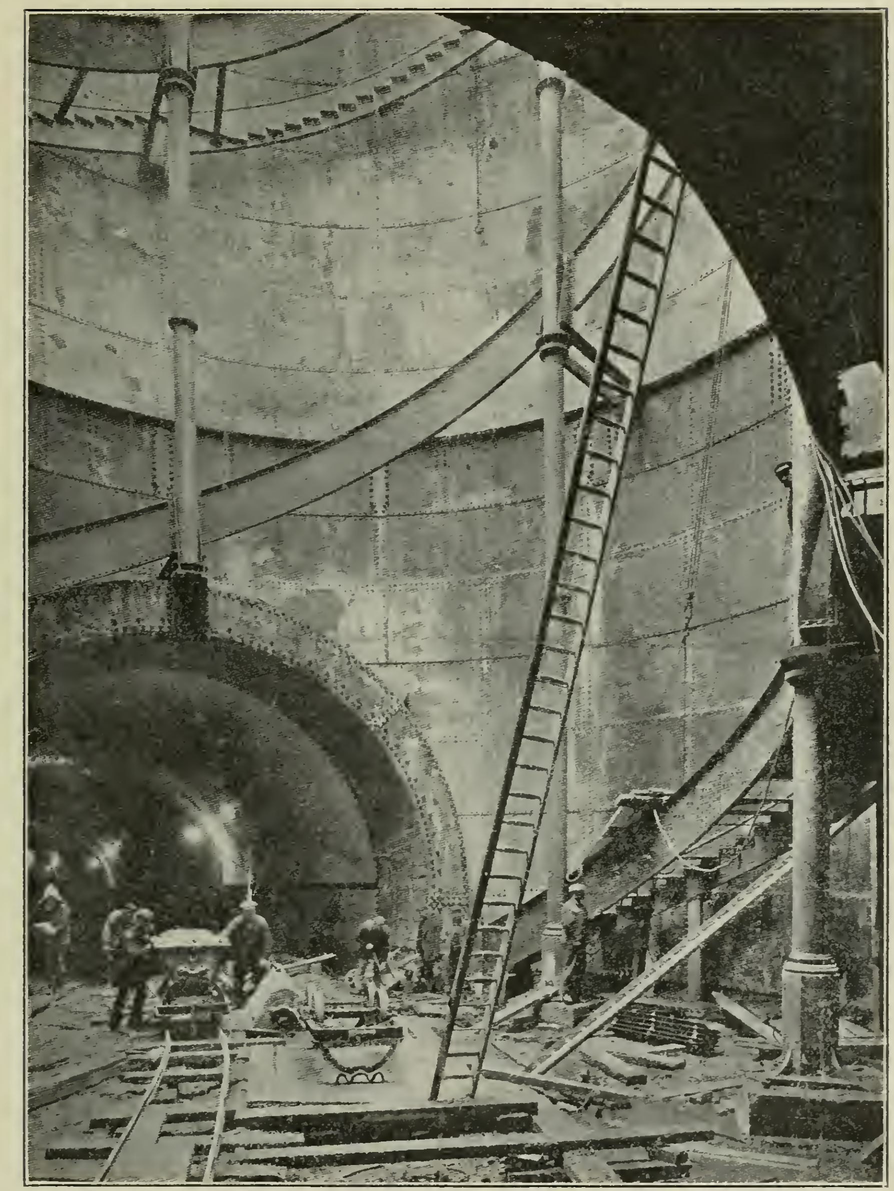
THE ROTHERHITHE TUNNEL AND SUBWAY

A new Thomes tunnel for fast passengers and vehicles, connecting Rotherhithe on the South and Steping on the north bank, begun four years ago, is fast approaching completion and in fact may be ready for opening when these lines come to the reader. Strictly speaking, the readers of *Compressed Air* have no business with this work, since compressed air was not employed in its construction, but the tunnel habit which compressed air has begotten leads to interest in all modes of construction and all subterranean and subaqueous engineering. This is practically a new London highway usefully supplementing the Tower Bridge and the Blackwall Tunnel and relieving the congested traffic in this very crowded and busy section.

The roadway begins with an open approach, an inclined cutting 900 feet long with an entrance arch and concrete walls. The roadway will be 16 feet wide with a foot pavement on each side 6 feet wide. Before entering the cut and cover section the East London Railway is crossed by a steel plate girder bridge, stairways in the side walls giving easy access to the roads above and to the railway station. The land tunnel is circular with an inside diameter of 27 feet and constructed of five rings of brickwork. At the end of this tunnel is shaft No. 1, the base of which is 70 feet below ground level. The shaft is double lined with steel plates, the space between being filled with concrete, and it has an inspection gallery running around at the top. At this point the cast-iron circular tunnel begins, the opening being finished with a grey granite moulding. This portion has an outside diameter of 30 feet and the inside diameter of 27 feet. The rings have a uniform width of 30 inches on the straight sections, each ring having 16 sections and a key. Inside the iron is covered with concrete lined with white glazed tiles.

Shaft No. 2 is much like the first, but is 102 feet below ground level and is fitted with a wide spiral staircase for public use, the stairs being supported on their inner ends by cast iron pillars. This shaft will be covered with a glazed roof.

The subaqueous section, the invert of which is 80 feet below high water level, is 1,500 feet long and ends in shaft No. 3 which is at the



SHAFT No. 3 ROTHERHITHE TUNNEL.

other bank of the river. This shaft, shown in the half tone, is practically a duplicate of shaft No. 2, with similar spiral staircase and glazed domed roof. Between this and shaft No. 4 there is a distance of a little more than 1,150 feet, the tunnel being driven to a curve of 800 feet radius. This is probably a unique instance of an iron lined tunnel with such a sharp curve. From shaft No. 4 there is another section of cut-and-cover work, followed by 1,200 feet of open approach, making the total length about a mile and a quarter.

Under the whole length of the cut-and-cover and the cast iron tunnels a subway has been built, having a brick arch and concrete base and sides. It has a width of 13 ft. 6 in., and a headway in the middle of 6 ft. 6 in. It is ventilated by grids in the roadway, has an open channel down the middle for drainage purposes, and is entered from manholes at the shafts and at the ends of the open approaches. This subway is intended to accommodate pipes, cables, etc.

Two shields were used, being lowered down shaft No. 3, one driving south under water and land and being broken up when it reached shaft No. 1, the other having only a short course in the other direction to shaft 4. A pilot tunnel was driven under the river before the tunnel proper by a special form of excavating machine, the soil being removed by trucks.

COMPRESSED AIR CALCULATIONS*

By E. A. Rix, Mem. Am. Soc. C. E., Mem Am. Soc. M. E.

Fellow Students:

The great progress in the Arts and Sciences is made for commercial reasons and by people who are seeking either gain or a livelihood. The trade catalogue is one means by which advance information is given the public, and in it the data and tables and scientific information are mostly theoretical. It is not considered prudent by business men to take the public into their confidence and give them the practical co-efficients which have cost years, much money, and hard work to acquire. For this reason, catalogue information is ofttimes very misleading, and is valuable only as a means of comparison.

No matter what theoretical engineering course we take, to be valuable to the community we must all take a post-graduate course of experience and become *commercial* engineers. The sooner we reach that degree, the better for ourselves and for everybody concerned. Theoretically and actually, you may have a million dollar ore body, but if it costs more per ton to realize its value than it yields commercially, there is not a cent in that ore-body. That, after all, is the only fact we wish to know, and we want to know it beyond a peradventure.

It seems to me, therefore, that if I am honest in my desire to help you, I must loosen up and give you practical, commercial co-efficients, show you how we safeguard our own interests, and at the same time satisfy those with whom we deal. And finally, it seems to be about the best way in which one can repay this University for the benefits which he has received from a four-years' training.

Before we undertake to solve a problem which I shall present for your consideration, I shall give you some of the practical data which I use to make these calculations.

During the last twenty years, I have kept a log of all the compressed air plants I have tested, and also the actual performance of a great number, covering almost every kind of compressor and compressed air motor or tool, and I have averaged all the indicator cards taken from the various compressors used in mining work and compared the indicated horse-power with the actual power required. Comparing this with the displacement of the compressor cylinders, I have concluded that for a safe and sane power factor, we must allow 20 horse-power for every one hundred cubic feet of cylinder displacement, to compress air from atmospheric pressure to 90 or 95 lbs. receiver gauge pressure at sea level.

I have made my calculations on these pressures because they are the standard pressures now used for pneumatic work, and nearly every machine and motor is constructed for these pressures. Twenty horse-power means brake horse-power, i. e., the power delivered at the shaft of the prime mover.

If you consult tables in any engineering magazine or trade catalogue, on air compressors, you will note that the power claimed to do certain work is much less than the figure which I give you, and in explanation, it must be noted that these tables are theoretical, and do not take into account the mechanical efficiency of the compressor, nor losses due to volumetric efficieny of compressors. These figures are therefore misleading, and should be avoided except to use as comparisons between one machine and another.

It is most unfortunate that the public is not given the results of working tests upon plants of all descriptions running under ordinary conditions, as such information is much more valuable than the records of official tests, which are usually made under special conditions by experts at the most satisfactory load—a set of conditions not often realized.

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*Published by courtesy of Mining Association of the University of California, before whom this paper was read February 19, 1908.

You must have a safe margin in your calculations so that neither you nor those for whom you are installing a plant will be disappointed, and I, therefore, have given you 20 horse-power per one hundred cubic feet of cylinder displacement as a figure that will never get you into trouble, and at the same time, it is not too generous. It may also be noted that it would be just as well in small plants to make no distinction between single and two stage machines. By small plants, I mean up to 400 cubic feet per minute capacity.

Second.—Remember that a compressed air cylinder will never give a quantity of air equal to the volume swept by the piston, for the reason that such things as clearance, leakage, temperature, piston speed, etc., reduce the theoretical quantity, so that it is best to figure about 80 per cent. volumetric efficiency for the average mining compressor. Many do not give 60 per cent. and some give 90 per cent.

Third.—In using compressed air at 90 lbs. pressure cold, it will take 24 cubic feet of free air per minute to give one horse-power in plain slide valve engines, and 15 cubic feet with good expansion valve gearing, and between these two limits will lie all the various types of engines. If the air be reheated, to about 300 degrees Fahrenheit, it will reduce the above quantities about one-third. In one hoisting engine which we installed, having compound Corliss cylinders, and where the air was heated to 400 degrees Fahrenheit before entering each cylinder, it required between 7 and 8 cubic feet only for one horse-power. Most mines, however, use cold air and prefer the power loss to the trouble and expense of the installation and maintenance of reheating apparatus.

Fourth.—The tables set forth in the trades catalogues for the air consumption of standard piston rock drills are fairly accurate and are generally in terms of the compressor cylinder displacement.

Fifth.—For operating ordinary station and sinking pumps of the direct acting type, which is the ordinary stock pump usually used in mining operations, it will be safe for you to calculate that one cubic foot of free air compressed to ninety pounds gauge pressure will do 135 foot gallons of pumping.

Sixth.—That ordinary mining hoists have a mechanical efficiency of about 75 per cent.

Seventh.—For the determination of pipe sizes, losses of pressure and terminal pressures for compressed air transmission, I use the Johnson formula, which is very satisfactory:

$$P_1^2-P_2^2=\frac{.0006V^2L}{A^5}$$

Wherein P_1=absolute initial air pressure
P_2= " terminal air pressure
V=free air equivalent passing through the pipe.
L=length of pipe in feet.
A=diameter in inches.

This formula is quite simple to solve.

With these facts at hand, we can now rapidly calculate the problem we shall consider as follows:

PROBLEM.

A mine having a water power distant 5,000 feet wishes to generate compressed air and transmit it to the collar of the shaft for operating purposes. The work to be performed is as follows:

100 tons of ore and waste to be hoisted in 20 hours.

30 gallons of water per minute to be pumped either at a station or a sinking pump.

5—2¼ standard piston rock drills to be operated.

3 air hammer drills to be operated.

General Conditions:

Depth of shaft, 600 feet.
Weight of skip and rope, 1,000 lbs.
Weight of ore hoisted, 1 ton.
Initial air pressure, 95 lbs.
Final air pressure, 90 lbs.
Altitude, sea level.
Geared hoist and unbalanced hoisting.

Required:

Size of compressor.
Diameter of air pipe.
Brake horse-power.
Altitude factors.
Re-heating co-efficients.

Note.—In problems of this kind, we must reduce all of our requirements to cubic feet of free air, because free air is the basis for all power calculations.

To determine the free air required for hoisting: If 100 tons of ore and waste are to be hoisted in 20 hours, the hoisting will be done at the rate of 5 tons per hour, and inasmuch as each load hoisted contains one ton, it follows that there will be a load hoisted every 12 minutes. Of course, we know that an absolute schedule of 12 minutes between hoists can scarcely ever be carried out, for the intervals may be shorter during one hour and longer during another, or stop altogether, but the only way to figure it is on a regular basis, and after that is determined, allowance one way or another can be made for any irregularity.

The load being 2,000 lbs. of material and 1,000 lbs. of rope and skip, makes a total of 3,000 lbs. which is to be hoisted 600 feet. 3,000 lbs. lifted 600 feet will require 1,800,000 foot pounds of work, or 54 horse-power, theoretical. Inasmuch as the hoist has a probable efficiency of 75 per cent., the 54 theoretical horse-power becomes 72 brake horse-power actually required.

Using cold air, it requires, as we have mentioned before, 24 cubic feet of free air per horse-power. Then 24 x 72=1,728 cubic feet of free air which the hoist will consume to make one lift. This, you will note, gives us direct results without taking into consideration the element of time or the dimensions of the hoist. If we made a hoist every 12 minutes, and it required 1,728 cubic feet to make a hoist, then the compressor must furnish 144 cubic feet of free air per minute continuously, and we must have storage capacity sufficient to accumulate the air between hoists. Right here is the vital point of hoisting economically with compressed air.

Let us assume in our problem that we hoist at the rate of 300 feet per minute, then it will take two minutes to make the lift, and the hoist will be lowering and idle during the next ten minutes. During this ten minutes, the compressor is delivering 144 cubic feet of free air per minute, or, 1,440 cubic feet total, which must be stored.

If the hoist is none too large for the work, you will find that if the pressure in the receiver drops more than one atmosphere or from 90 lbs. to 75 lbs., that the hoist will not operate in a satisfactory manner. Then, in our problem, if we must draw 1,440 cubic feet from the receivers at a drop of one atmosphere in pressure, the receivers must have a cubic capacity of 1,440 cubic feet, and if the hoist is amply large so that it will still operate after the receiver pressure has dropped two atmospheres, or from 90 lbs. to 60 lbs., then the receiver capacity can be one-half of 1,440 or 720 cubic feet, but it is not wise to go below this pressure, because it will affect too materially the pressure required for operating the other machinery.

For a first class job, install receivers having a capacity equal to the storage required at one atmosphere pressure. Right here let me say that large receivers cost less in proportion to their storage capacity than small ones. For example: A carload consisting of four receivers 54 inches in diameter by 30 feet long, containing about 2,000 cubic feet, costs at the present time about $1,600, while the same storage in ordinary receivers 48 inches in diameter and 12 feet long, would cost about $2,200. It is better to invest more money in receivers and less in compressors, because the smaller compressor takes less power at the peak, and most power bills are figured on a constant peak.

If you install a plant and the receiver capacity is too small, you can always determine the proper quantity of storage by running the compressor with the unloader cut off, and if the receivers blow off between hoists and the pressure drops more than 15 pounds during hoisting, add more receiver capacity until it will not blow off nor drop more than 15 pounds. If you arrive at the point where it does not blow off and the pressure does not fall to 15 pounds, then slow down the compressor until the desired drop is reached, and you will be operating your plant at the most economical point. Then cut in the unloader again and let it work when it will. An unloader only saves wear and tear in the compressor where you buy power at the peak load, as happens in most cases, but does not affect your power bill.

Let us go back now to our problem. We find, therefore, that 144 cubic feet per minute is required for hoisting. Now, while we have allowed four hours in twenty-four, or an hour and twenty minutes on each shift for hoisting and lowering men, timbers, supplies, etc., it is entirely probable that at least once every hour some one will be going up and down the shaft, and it would be practical, therefore, to say that the hoist would handle six loads per hour instead of five, and we must therefore add twenty per cent to the hoisting requirements, making, say, 175 cubic feet instead of 144.

To determine the amount of compressed air required for pumping: For pumping 30 gallons per minute 600 feet, requires 30x600 or 18,000 foot gallons of work. If one cubic foot of free air at 90 pounds gauge pressure will give 135 foot gallons of work, we shall require 133 cubic feet of free air for the pumping. This requirement is constant.

To determine the amount of compressed air required for drilling: Five 2¼-inch rock drills will require 50 feet of free air each, or 250 cubic feet, and three air-hammer drills will require 25 cubic feet each, or 75 cubic feet. To get these amounts, take about eighty per cent. of the requirements as stated in rock-drill catalogues, which always give quantities in compressor-cylinder displacement which do not deliver on an average within twenty per cent. of their displacement, excepting in large machines.

Our total requirements will therefore be:

Hoisting	175 cubic feet
Pumping	133 cubic feet
Drilling	325 cubic feet
Total	633 cubic feet

This 633 cubic feet does not take into consideration any ordinary pipe leakage in the hoisting works and below ground, and in conducting this air from a distance, inasmuch as our problem calls for a transmission of 5,000 feet, it would be well to allow a leakage of five per cent. on the entire system. This would bring our requirement up to 665 cubic feet, and if we allow that our compressor will give a volumetric efficiency of at least eighty per cent., we must have a cylinder displacement of 830 cubic feet per minute.

You will remember that our power factor was 20 horse-power per 100 cubic feet; consequently we must have 166 horse-power delivered on our water-wheel shaft to drive this compressor.

Finally, we must determine the size of the pipe, allowing five pounds drop in pressure for friction loss. You will remember the formula.

$$P_1^2 - P_2^2 = \frac{.0006V^2L}{A^5}$$

P1 the initial pressure absolute=95+14.7 or 109.7, and its square is 12,034.

P2 the terminal pressure we have stated shall be 5 pounds less than the initial or 90 pounds, of 104.7 absolute and its square is 10,962.

The difference between these two, or—

$$P_1^2 - P_2^2 = 1072.$$

Substituting this in our equation, and also the values for L and V, we have—

$$1072. = \frac{6 \times 5000 \times 633 \times 633}{10000 \times A^5}$$

Reducing, we have $1072 \times A^5 = 3 \times 633^2$, or

$A^5 = 1121$

A=4-in. pipe.

We have now to figure the size of the compressor required. If you happen to have tables and catalogues at hand, it will be an easy matter to look up a satisfactory compressor having a displacement of 830 cubic feet, but if such literature is not at hand, the size of the compressor may be determined as follows:

It almost goes without saying that you would select a two-stage compressor for anything over 400 cubic feet capacity. This two-stage compressor will have a low-pressure or gathering cylinder, wherein the air is compressed to about 25 pounds, and a high-pressure cylinder where the air at 25 pounds after it has been cooled will be compressed to 90 or 95 pounds pressure. The reason a two-stage machine is selected is because it has a higher volumetric efficiency, requires less power to operate it, is easier to lubricate on account of low temperatures and has less strains on the mechanism.

The first thing to consider is the speed at which you will operate the compressor, and this will be dictated by many things. If you have a limited amount to expend, you will naturally select as high a working speed as possible, because the higher the speed, the smaller the compressor.

Again, you may have to take the future into consideration, and you may want more air later on, as the shaft goes deeper or more water is encountered. You would then naturally select such a speed as would give you the margin of additional power required.

You may take 150 revolutions per minute as the maximum for compressors from 400 to 1,500 feet capacity, and 100 revolutions per minute as a speed that will give you a fifty per cent. margin for the future, so let us assume that the mine in question has a future, and take 100 revolutions per minute. If our requirement is 830 cubic feet per minute we shall then require an intake or compression cylinder which will give us 8.3 cubic feet per revolution, and inasmuch as the cylinder is double-acting—that is to say, makes two displacements per revolution, the cylinder must have a cubic capacity of 4.15 cubic feet.

Experience dictates that the average compressor cylinder is built for the following strokes and capacities:

6-in.	stroke	up to	50-ft.	capacity
8-in.	"	"	100-ft.	"
10-in.	"	"	200-ft.	"
12-in.	"	"	500-ft.	"
16-in.	"	"	700-ft.	"
18-in.	"	"	1500-ft.	"
24-in.	"	"	2500-ft.	"

Our compressor will therefore be best suited by an 18-inch stroke, or 1.5 feet. If the capacity is 4.15 cubic feet and the stroke 1.5 feet, the area of the cylinder will be $\frac{4.15}{1.5}=2.75$ square feet or 397 square inches, which is the area of a 22¼-inch cylinder. The low-pressure cylinder will therefore be 22¼×18.

It is very evident that if we have two cylinders to do our compressing, there is no good reason why one cylinder should do more work than the other, and there is a very good reason why the work performed by these cylinders should be equal, viz: because the total work and temperature developed will be at a minumum, just why would lead us into mathematics, and so you must take the statement as a fact.

There is also the mechanical reason that the strains on the machine will be at a minimum, and if you construct the compressor of the duplex type, both sides will be alike, except as to the cylinders. It can be easily shown by algebraic method that if our two cylinders perform equal work, the intermediate pressure must be a mean proportional between the initial absolute pressure and the final absolute pressure, and the cylinder ratios will be as the ratios of either the high or initial absolute pressure to the intermediate. In other words, to put this in such shape that you will easily remember it,

If P =absolute initial pressure
P_1 =absolute intermediate pressure
P_{11}=absolute final pressure

then $P_1=\sqrt{P\times P_{11}}$

Take our example: Our initial pressure is atmospheric, or 147 absolute. Our final pressure is 95 pounds gauge, or 109.7 absolute. The intermediate pressure will then be $P_1=\sqrt{14.7\times109.7}$ or 40 pounds absolute=25.3 pounds gauge pressure. Our proportion then stands 14.7:40::40:109.7, which represents a ratio of

$$\frac{40}{14.7} \text{ to } \frac{109.7}{14.7}=2.74$$

The cylinder ratios will therefore be indentical with the pressure ratios, and our high-pressure cylinder will have a capacity of $\frac{1}{2.74}$ of the low pressure. The strokes being the same, the area of the high pressure cylinder will be $\frac{1}{2.74}$ of the low pressure, which was 397 square inches. Dividing this by 2.74, we have 145 square inches as the area of the high-pressure cylinder. This corresponds to a diameter of 13½ inches. The compressor will then be a 22½-inchx13½-inchx18inch stroke, and you will be justified in taking the nearest size to this that the manufacturers can supply.

You will note that as the altitude increases, the initial absolute pressure diminishes, and as the final pressure remains the same, the pressure ratio grows larger as the altitude increases. For example: At 10,000 feet the atmospheric pressure is ten pounds, instead of 14.7 pounds, and if you go through the same calculations that we have just made, you will find that the cylinder ratios will be 3.3 instead of 2.74, and this will make the high-pressure cylinder only 12½ inches in diameter instead of 13½ inches in diameter, and the intermediate pressure will be 18.3 pounds instead of 25.3 pounds. Such a compressor would not, however, be able to do the work contemplated in the problem we have considered, for the reason that while the weight of air necessary to do work remains practically the same for reasonable altitudes, the capacity of the compressor diminishes as the altitude increases. It is true the volume remains the same, but it has not the weight and therefore you must increase the size of the cylinder required at sea level by the ratio between the ratio of compression at sea level and the ratio of compression at altitude.

In our problem, the ratio of compression at sea level is 7.5 and the ratio of compression at altitude of 10,000 feet is 11. The sea level compressor must be increased therefore, $\frac{11}{7.5}$ or 1.47 times, to give the same weight of compressed air at 10,000 feet altitude, or, to put it even more simply, it will take 11 strokes of the same-sized compressor piston at 10,000 feet altitude to give the same compressed air or to do the same work as 7½ strokes will do at sea level.

In our problem this would make a low-pressure cylinder of 27 inches instead of 22½ inches, and a high-pressure cylinder of 15 inches instead of 13½ inches. In other words, this altitude compressor is nearly fifty per cent. larger to do the same work.

A proper understanding of these simple calculations will enable you to check up compressor sizes and proportions, and no one could furnish you with a sea level compressor for an altitude one, and *vice versa.* We have assumed eighty per cent. volumetric efficiency in this problem, but if the compressor happens to be a slow-speed, mechanical-valve machine, ninety per cent. could be assumed. The figures I have given you are safe, and taken from average plants, and it will be necessary for you to use your judgement is assuming a higher or lower factor.

To determine the amount of compressed air required for re-heating: It is practical to re-heat air from 300 to 400 degrees Fahrenheit in various ways and great economy realized, especially for pumping and hoisting, and if it is possible you may reduce the quantities of cold air which we have figured for this work by the ratio of the atmosphere to the compressed air temperature absolute. Thus, if the atmosphere is at 60 degrees Fahrenheit, or 520 degrees absolute, and the compressed air is used at 300 degress Fahrenheit, or 760 degrees absolute, then the cold air volume for your work may be taken at the ratio of $\frac{520}{760}$, or about seventy per cent., thus making a saving of thirty per cent.

In conclusion, let me caution you about being led astray by that Will-o'-the-Wisp, "Efficiency." When you come to choose between compressed air and some other power to do mining work, "Utility" should always be the standard for comparison.

It is seldom that any set of conditions calls for the exclusive use of one kind of power, and it is not good engineering to make an installation the victim of any fad or prejudice. Whether it be steam, electricity, water power or compressed air, or a combination of any or all of them, let the sole and only qualification be determined on the basis of *commercial* efficiency.

CHARGING MACHINES FOR CUPOLAS*

The designers are indebted to the blast furnace operators for the idea of the charging machine. Every one is familiar with the skip hoists and the great saving effected over the old practice of using elevators and dump buggies pushed by laborers. This refinement in handling charges naturally was introduced by the blast furnace people, as their operations are continuous for months, 24 hr. a day. The elimination of laborers made tremendous economy in cost of production. The skip hoist is an end dump and is fitted with automatic features which would not be applicable to the conditions in cupola practice. There have been end dump machines used for cupolas, and the author believes such a device is in use at the Pennsylvania Car Wheel Company. The Whiting Company has adopted the side dump, claiming it to be simpler and better for continuous movement of cars. Other advantages are that there is less handling of cars and a narrower charging floor is permissible.

The construction of the Whiting pneumatic machine is illustrated in the drawings. Fig. 1 gives elevations of the machine with the car

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*From a paper by G. R. Branden, read before the Pittsburgh Foundrymen's Association March 2, 1908.

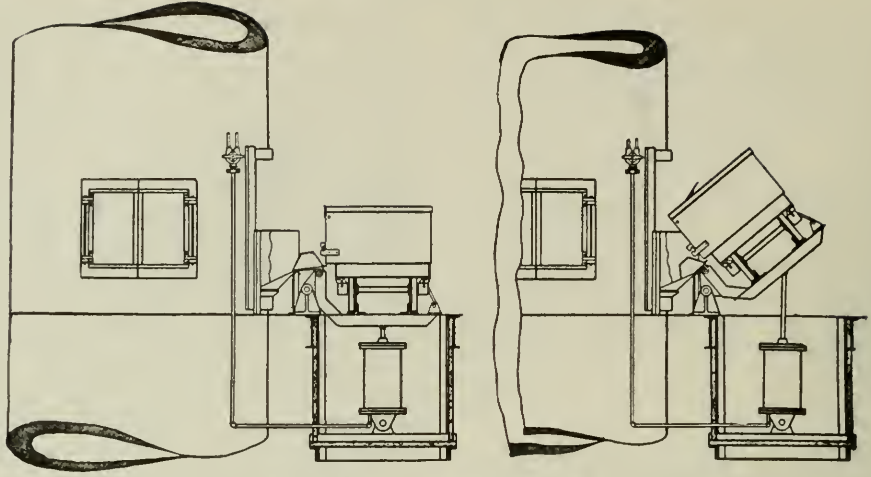


FIG. I.—CUPOLA CHARGING MACHINE WITH CAR READY TO DUMP AND IN DUMPING POSITION.

in position ready for raising and in dumping position. The machine consists of a platform hinged at a level above the charging platform on the side toward the cupola, provided with a track for the charging car in line with the stationary tracks, guard angles, as shown, and a hook for holding the car to the platform when being dumped. A dumping cylinder is supported by framing attached to the charging floor and pivoted to allow the slight swing required when the platform is tipped. The piston rod is pivoted in a bracket attached to the underside of the platform. The platform is constructed of structual shapes and all joints

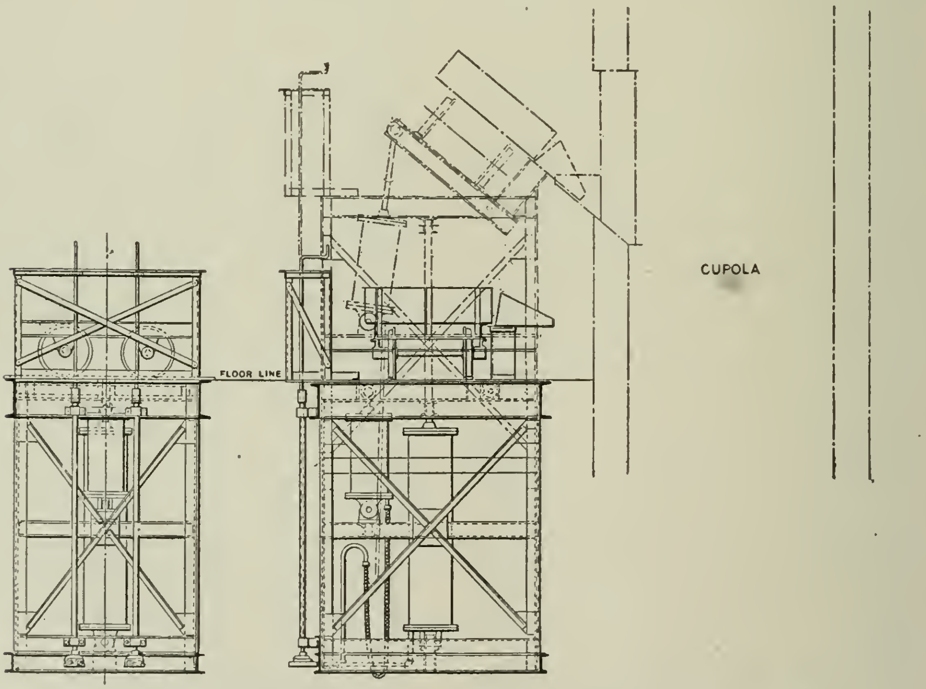


FIG. II.—FRONT AND SIDE ELEVATIONS OF A COMPOUND CUPOLA CHARGING MACHINE ARRANGED TO ELEVATE CAR BEFORE DUMPING.

are strongly riveted; the hinge pins are of ample size and are arranged for easy removal and replacement. An apron plate is hinged to the platform and laps over an inclined chute in front of the cupola door. The controlling valve is located at any convenient point and is piped to the cylinder and connected with the air supply.

In operation, the car is run on the platform and the hook engaged with an eye attached to the car frame. Then the valve is opened to admit air into the operating cylinder, and the platform is raised to the dumping position. The iron charges are put on cars with ends about 12 in. high, but open on both sides. Coke cars have ends and sides inclosed, one side being fitted with a hinged door. By manipulation of the valve the charges may be distributed as desired. The level of the charges must be maintained 3 to 4 ft. below the level of the door sill to get the best results. Electric power may be used in place of compressed air, using a geared hoisting machine. The ordinary crane controller will give the different movements and speeds required.

A device of this character is necessarily of greatest benefit where the cupola output is large and the speed of melting relatively high. A cupola 54 in. in diameter inside of lining is about the smallest size which should be charged by machine. With a No. 9½ Whiting cupola, 90-in. shell, 72 in. inside diameter, and melting 20 tons per hour, two men with the charging machine perform the work which would otherwise require five or six men. Assuming the duration of heat to be 4 hr., the saving in labor will be 12 hr. time, at, say, 17½ cents, or $2.10 per day, which represents an annual saving of $630, or about 200 per cent., on the investment.

The charging door in the cupola for use with this machine is 9 in. above the charging floor. To obtain maximum economy of fuel the charging floor should be from 20 to 24 ft. above the bottom plate, or about 5 ft. higher than for hand charging. Other charging doors, at ordinary hight for hand charging, are located at the sides for use in emergency, and for leveling the stock charged by the machine if this should ever be necessary.

The company has devised a compound machine, shown in Fig. 2, for use in connection with low charging floors, consisting practically of an elevator of the plunger type, which lifts the car and charging machine together to the required level. The two mechanisms are controlled independently and may be operated by pneumatic power, as shown, or by electric power. The original charging doors may be left in the cupola, being shifted as necessary, and used for hand charging and leveling.

DRYING WOOD

The question was recently asked, "What do you mean by stating that a drykiln should be arranged to dry by means of a natural draft as being most economical and effective, also automatic in its operation?" To answer briefly, drying by natural draft is an arrangement using only heat and the moisture in the lumber to circulate the air or give draft to the kiln using the open-air method; or, heat, the moisture in the lumber and cold water, in the condensing method. One advantage is, over that of some of the force-draft methods, in having as applied by the sun a radiant heat within the room.

Its economy is partly in the fact that it is automatic, the movement of the air being quickened by the moisture absorbed (the air becoming lighter as moisture is absorbed in the form of gas), and as the moisture decreases (the lumber becoming dry) the air becomes less rapid in its motion, although increasing in temperature. In the force-draft method the draft, being created by force outside the kiln, plainly cannot be automatic or natural, and is only capable of regulation by constant attention of the operator.

The changing methods of drying have been brought about also by reason of the continued demand for better work from the manufacturing wood-worker. The first method—that of the fan—came undoubtedly from the observation of the effect of the wind in drying, without any understanding of physics or that Nature's method of drying the tree is to destroy it as quickly as possible. Then, to save the cost of the fan and the cost of its operation, came the chimney-draft method. This was followed by the repression, or what we term the moist-air natural-draft kiln, as being less influenced by air pressures (winds and changes of climate). Lastly, we have the condensing kiln which, not being open to air and using a strictly natural draft is, while of more perfect control, also of much better economy in its operation, and came only by reason of the demand of the manufacturer for better economy in the use of steam and more perfect drying of the product.

All methods mentioned have survived, the two first by reason of their more rapid work on softwoods, when the difference in value of low-cost steam in greater consumption is held to be balanced in the lessened cost of amount of radiation needed, but, in using exhaust steam by applying in part direct, it possibly dooms the force-draft method of drying lumber.—E. E. Perkins in *Woodworker.*

VOLUMETRIC EFFICIENCIES OF AIR COMPRESSORS

At the Royal Technical College at Dresden, Germany, W. Heileman, using the special compressor installed there, has recently made some investigations of compressor efficiences. The compressor is belt driven and has three cylinders, only two of which were used in the tests. These cylinders were: *A,* 10.2 in. diameter by 11.8 in. stroke, double-acting, with tail-rod and oscillating rotary valves; *B,* 8.65 ins. diameter, 11.8 ins. stroke, single-acting, poppet-valves. The delivery pressures were varied from 21 lbs. to 114 lbs. per sq. in. (gage), and the speeds from 52 to 108 r. p. m. The chief quantities obtained from the tests were: (1) The ratio volume of air at suction pressure to piston displacement, called volumetric ratio; (2) the ratio of air volume measured under atmospheric conditions to piston displacement, called capacity ratio; (3) the ratio of isothermal energy of delivered air to the indicated work of the compressor, called indicated efficiency.

For cylinder *A,* the volumetric ratio varied from 93.4 to 97.2 per cent., the capacity ratio from 73.0 to 91.9 per cent., and the indicated efficiency from 55.1 to 76.8 per cent., when the rotary valves were worked without pressure equalization. Substituted valves with pressure equalization gave materially lower figures, namely volumetric ratios of 92.9 to 95.1 per cent., capacity ratios 57.8 to 84.4 percent., and indicated efficiencies of 42.4 to 68.5 per cent. The indicated power in both series of tests ranged from 4 to 20 HP. Cylinder *B,* fitted with poppet-valves, gave the following results, with indicated powers of 1.6 to 7.9 HP. Volumetric ratio 90.2 to 94.5 per cent., capacity ratio 83.2 to 94.5 per cent., indicated efficiency 63.4 to 73.1 per cent.

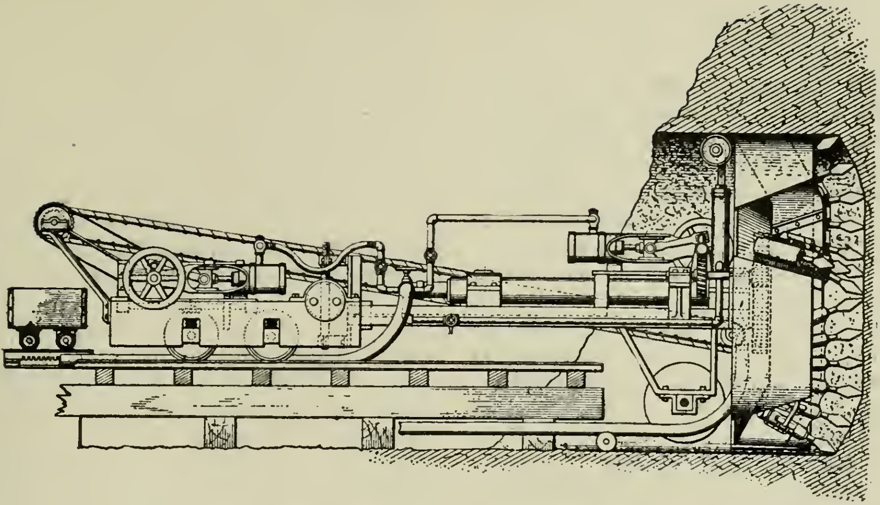
The results show a very variable relation between volumetric ratio and capacity ratio, which latter figure is of most practical interest. An attempt to calculate the latter from the volumetric ratio, full temperature observations being made, gave results differing from the true value by the maximum amounts of 7 per cent., 21 per cent. and 34 per cent. in the three series of tests. The amount of cooling water used in the cylinder jackets was found to have little influence on the volumetric ratio, but naturally a considerable influence on the capacity ratio, the latter being increased by increased cooling. Both the capacity ratio and the indicated efficiency decreased with increasing ratio of compression and the decreases were considerably larger in cylinder A than in the other.—*Zeitschrift des Vereins Deutcher Ingenieure.*

THE PROCTOR TUNNEL BORING MACHINE

It seems to be somewhat obligatory upon us to show this machine, at least as a mechanical curiosity and as illustrative of the daring of the modern inventor. It is an air operated machine and has been actually built, although it has as yet no actual record of performance.

The cut, which we produce from *Mining Science,* shows the construction and the principle of operation of the machine with remarkable clearness. The idea is to cut a circular tunnel out of the solid rock exactly to the required dimensions leaving the surface smooth and true. The material removed is all cut up into fine chips instead of being taken out in rough masses of portable size. There is no drilling of holes and no blasting and the machine can work and advance without interruption.

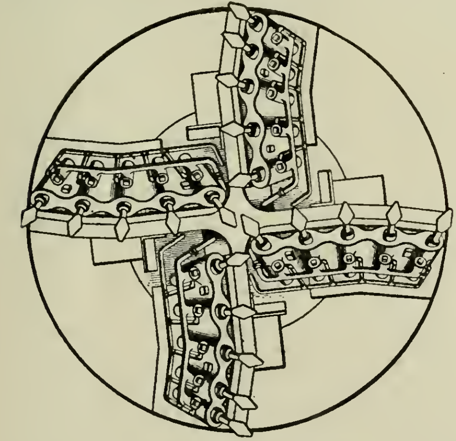
The cutting head is attached to a large hollow shaft, which in turn is mounted on a heavy "I" beam. This is supported by frames carrying large supporting wheels which bear on the floor of the bore, keeping the head in position and allowing it to progress as the breast advances. The position of the head is steadied by the use of a smaller wheel held in contact with the roof of the bore by the use of a rod and piston actuated by air pressure from below. At the rear end of the "I"



THE PROCTOR TUNNEL BORING MACHINE.

beam there is a jointed connection with the frame of an operating truck. This joint is so arranged that the position of the head can be adjusted to change the direction of advance, either laterally or vertically.

The working head rotates slowly inside of a short cylinder or shield and carries a series of scoops which take up the debris from the lower part of the shield and, carrying it up and over, delivering it to a hopper, which in turn feeds it to the conveyor belt. This belt carries the debris back and delivers it to the car which stands on the tunnel track underneath and in the rear of the operating truck.



FACE OF CUTTING HEAD.

The cutting head is composed of four arms which of themselves are composed of a series of cylinders, each one of which operates an individual cutting tool by compressed air. They are simple in construction and act on the principle of the air hammer. The tools are so arranged as to give an oblique blow and are designed to follow as nearly as possible the natural chipping action ordinarily used in the surfacing of stone. They are made with a bit similar to the ordinary moil. The arrangement of the cylinders in the arms of the cutting head is such as to "stagger" the circles of cutting so that no two bits will follow the same path. They are spread somewhat in a fan shape, so as to reach all points of the breast from the center to the extreme edge of the bore which is a trifle larger than the shield. The operating truck runs on a special track and is equipped with a pinion which engages in a rack attached to the trackbed. This progresses the truck, and with it the cutting head and is readily regulated as to the speed of the advance by the use of a disk regulator. By this same means the action is reversed and the entire machine is backed away when required.

A REPORTER GOES THROUGH THE TUNNEL UNDER PRESSURE

When the opportunity came of going down into the Pennsylvania East River tunnel and of being the first man outside the working force to gain Long Island City by this unusual way, soon to be daily followed by millions, I confess I knew almost as little of the world-wonder which has been accomplished in our midst as any other New Yorker. We are convinced that all live in no "mean city," but as to the details we are all, I think, a little vague.

My idea was that I would hop down a ladder, and, once in the tunnel, mud-lark my way along until out of the muck and mist the glories of Long Island City, which I had never seen plainly, would burst upon me. Should I wear a mackintosh or a rain coat or rubbers were the questions which agitated me.

Once I reached the caisson at the foot of Thirty-third street, from which the tunnels begin their mucky way, my plans were made for me. A doctor applied an instrument to my heart and guaranteed me to withstand high and hot air pressure for the space of half an hour.

"Now don't let those 'sandhogs' keep you down there all day," he said, in kindly warning. "They will want to show you everything. Cut it out and come back in half an hour."

In a trice I was dressed like all the sandhogs and looked, I felt, very much like a stage version of Jules Verne's Captain Nemo about to prepare for twenty thousand leagues under the sea. We were soon aboard an elevator in the caisson, and sinking with many rough jolts into the bottom of an apparently endless shaft. At last we came to our moorings with a rough bump, and I steppd out; to all appearances I had made a mistake in the stage drop and would have to begin all over again. I seemed to have fallen into the lower stories of the Hotel Belmont or some other of the modern buildings which extend as far toward the center of the earth as they do above the conservative steeples of our fathers.

We were in a subaquious or subterranean—I am not quite sure which—palace of tiled brick, lighted by electricity to twin the brightness of the most garish day. I was turning to look for the subway station, the barber's shop, the broker's office, perhaps the bar, for clearly they all had their place and position in this palace of modern life, when suddenly, drawn by magic it seemed—an endless cable I afterward learned—a whole convoy of muck carts came into view, loaded down with the débris of the East River's last resistance to the power of compressed air and hydraulic jacks.

We followed the tunnel in an atmosphere that was sweeter and cleaner than any cellar I had ever entered, and pushed along for a hundred yards or so, until our way was blocked by a huge boiler, heavily riveted and clamped, as though contrived to keep within its belly some demon destructive of man and his works. A little mantrap was opened, and we crept into this metallic coffin, the trap was closed behind us, a man opened a lever, and in a few seconds our coffin was filled with a dense mist. He was only three feet away, but I could only dimly see the man who held the lever, and the man who watched the air clock had disappeared from view.

"Not so fast, not so fast,"suggested Mr. Moir, the great boss of the great hundred-million-dollar job. The man reversed the lever, and the atmosphere cleared as if by magic.

"I suppose you never knew why fogs occur," said my amiable mentor. "It is the contact of different atmospheric pressures. We must sit here until the atmosphere is equalized. When we entered it was normal. When we make our exit it will exercise a pressure of fifteen pounds to every square inch of our bodies." Slowly, and with infinite care, the high-pressure atmosphere was admitted. Now and again there would be a rush of fog, instantly banished by a gesture from the all-controlling boss of the job.

"Ain't it awful," murmured one of the "sandhogs," probably impatient at the careful slowness of my initiation to strange atmospheres. "If he can't blow air out through his ears he'll have to go back."

Now, the pressure was quite considerable. I was made to stand up. My mouth was as dry as the sands of the Sahara, I was ordered to swallow continually, then through my ear drums ran a sharp pain. "I will hold your nose tight, pull it even if you don't mind, and then you'll blow." I blew, and out of my ears came the winds, or they seemed to, as from the cave of Boreas.

"Jimmy" Sullivan and Ryan, the premier "sandhogs," were delighted.

"You done it and you done it beautifully," they said. It was pleasant to think that while I contributed nothing to the great work, and in nowise deserved the piece of the cutting shield with which they afterward honored me, the flexibility of my ear drums and the openness of my air tubes had prevented me from retarding the great work.

Now the atmosphere was equalized, both clocks [pressure gages] agreed, the door of our iron coffin at the opposite end to where we had entered was opened and we stepped out into the new atmosphere. In this zone the tunnel, the last of the four, was nearly completed, even to the finishing polish and furbelows which tunnels receive as well as gowns—the concrete men were on their job, and only the passing of the mud carts told that far ahead men were still at work in an atmosphere of mystery and danger. We staggered along, or seemed to, and every one I I saw seemed to walk with a sailor's roll. Soon we were seated in another, and the last air lock, having our systems toned up to an air pressure of 31 pounds to the square inch of body surface.

"Jimmy" Sullivan had my nose in a vicelike grip, and I blew out the air through my ears. It was nice to have him say again I "done it beautiful," but suddenly the master of the job shattered all my illusions as to my new accomplishment.

"You think you are blowing air out through your ears; it feels that way, and I could talk till doomsday without convincing the "sandhogs" that they are not. The fact of the matter is you are admitting the air of the new atmosphere into your head, and if you didn't it would burst your ear drums; you see the air pressure has to be equally adjusted."

"What would happen if while we are still half way suspended, as it were, between atmospheres the door of the air lock should come open?" I inquired.

"We would burst," said the master boss. "The air clash would be tremendous—we would be torn to pieces."

"No," said Ryan, who loves to live at the head of the cutting and has to be forced home at nights. "No one knows whether we would be torn to pieces, for there are never any pieces left. Once I have heard big Bill tell about a job he was mixed up with, and how ten men were sitting in the air lock when the door burst, and you know them ten men altogether didn't make a grease spot.

"Blow hard, blow hard," said "Jimmy" Sullivan. The pain in the ear drums passed with the rush of air, and we passed out into the thirty-one-pound-pressure atmosphere.

You can do anything down there that you can do in our normal atmosphere but whistle —that faculty is lost. Out of the thousands and tens of thousands of men who have worked in the tunnel at the front of the heading only one man could whistle, and he died suddenly one day whistling "Down on the Suwanee River," and the doctors said he had the lungs of a bull rather than those of a man.

We staggered along now in the muck and the mist. Each man was doing his allotted task calmly and gravely, but all men knew that death was not far away if only by the escape devices. We climbed into the refuge fifty yards behind the heading, and Mr. Moir explained convincingly how any man who reached here was safe from inundation, "blowouts," and all the other dangers which beset the "sandhog." "He would become encysted as it were, in the air cell, and nothing could reach him. We have only lost two men since our safety screen was erected. One poor fellow was bringing his shovel with him. He got it jammed in the door and the waters overtook them."

Stumbling over timbers, air pipes, electric wires, clay bags to blow into leaks we staggered along to the shield and the cutting edge. The shield is a wonderful machine, but you will never understand it from my description, for a realizing sense of the steel monster you will have to see it yourself. Around the shield which fills the whole circumference of the tunnel are arranged twenty-seven hydraulic jacks which force the hardened cutting edges through every kind of geological formation, mining and dynamite assisting when most stubborn rock is encountered.

In the murk and the mist and the drenching fog already we could see the glint of the shield that had traveled from Long Island City, and we could see that the two powerful engines were only eighteen inches apart. The jacks were started, the shields quivered and shook, they moved forward, like caterpillars resting on their tails, and soon they touched all around the circumference, but for an impertinent rock lodged in one corner. "Jimmy" Sullivan was for blowing the thing to smithereens, but Moir said:

"No bulldozing, boys, now, least of all when we have got the East River, backed by the Atlantic Ocean, just where we want 'em." Quietly he plotted the destruction of the rock, and together we climbed into the Long Island shield, while both gangs cheered the completion of the work and the man who had been with them and guided them from start to finish.

"Now you have an idea of the conditions under which the battle has been fought," explained the master builder. "All we have had to do really was to keep cool and not get excited. I think we have done that for four years, and the rest was easy. We have kept the water out of our tunnel by compressed air, and we have used the water to do our digging and our cutting for us. You have got to keep this air pressure nicely adjusted to the water pressure from the river or you will have blowouts. One half pound of air, speaking roughly, holds about two feet of water, so there's the problem. Watch your water pressure and then meet it with its conqueror—air.

"Generally we have our air compressors making 70 revolutions the minute, but in times of great emergency we have put it up to 240 revolutions, which produced 70 pounds of pressure to the square inch, and then the water always backed out gracefully. The problem is to keep the water out without blowing off the roof of the heading, and I tell the heading bosses 'Don't be afraid of working in wet feet. Let the water ooze in at the bottom; its better that than making a hole for the whole river to pour in at the top.'"

As we turned to go, "Jimmy" Sullivan was getting to work with his fearful pet, which is known in science, but not to "Jimmy," as an hydraulic erector. It looked like a useless mass of battered iron, but "Jimmy" touched some valves and pressed some buttons, and it began to move around with the grace of a butterfly. "Jimmy" watching and guiding it snooped along the floor of the cutting, thrust out a link into which a "sandhog" thrust a staple, and then, as though it were lifting a feather, it carried the last segment of the last iron ring, weighing a ton, and dropped it into place—practically the tunnel was finished.

When we reached the elevators it was dark outside, the day was gone, and the doctor was apprehensive that I should soon be on his hands with the "bends." All the walking bosses, where we had our coffee. were a little sad, for undeniably the great job is finished and the glorious day of the "sandhogs" is over. —Stephen Bonsal in *New York Times*.

THE BOSS OF THE EAST RIVER TUNNELS

Over the great submarine construction which would be regarded as a wonder of the world if in this progressive age and generation we had time for admiring and congratulatory pauses, E. W. Moir, vice-president of the Pearson Construction Company, has presided day and night for four years. The other men have worked in eight-hour shifts, with the pleasing interlude of pay Sunday every other week, but he has worked for four years without intermission. His belongings have lived in a spacious apartment near the top of one of the new sky-scraping hotels, and when he goes to bed, which is seldom, according to the sand hogs, Mr. Moir has a telescope glued to his never-closed eye. Certain it is that from his eerie den you can see the air bubbles in the river proceeding from the tunnel, and he has always turned up on the job before the telephonic message of a "blowout" or some other of the hundred and one obstacles which have beset the undertaking could reach him.

Mr. Moir, the right-hand man of Sir Weetman Pearson, who has so many hundred-million-dollar jobs going on in different parts of the globe that he only comes to New York once a year, is the most eminent practitioner in compressed air that the world has ever seen, and he is yet on the sunny side of 45. The only flaw in his record is that he was born on the west coast of Scotland, but for him America has spelled opportunity, as it has indeed for all the men of the twenty-two nationalities who have worked under him on the great job.

He talks about compressed air as Sardou or Clyde Fitch talk of the stage, with love and respect, but without familiarity. "Compressed air is like a doctor," he says. "Never call him in unless you have to. If you have to, why that is all right." Moir likes to talk about Lord Dundonald, who was an Admiral in all the navies of the fighting world before the British Admirality would give him his chance at home, as the first man who suggested the use of compressed air in submarine tunneling, and he has great praise for Mr. Greathead and De Witt Clinton Haskins, the American, who began the luckless brick tunnel under the Hudson in 1890, with Moir at his side, but in the annals of the Royal Society of London, before which august body Mr. Moir will shortly describe the East River achievement, you will find him constantly referred to as the builder of the Blackwall tunnel and the pioneer of compressed air work.

He has had his ups and downs like all men of achievement, and the reward for his, in view of the primitive tools at his disposal, almost incredible work, under the Hudson in the nineties was a mechanic's lien on a hole in the ground two thousand feet long, but in this failure, which was a failure only in the sense that timorous capital was not forthcoming to complete the undertaking, he acquired the knowledge and trained the men, both of which were needed to tunnel the Thames in London and the East River in New York.

The men who have followed Mr. Moir from the North River to the Thames and then from the Firth o' Forth Bridge back to the East River tunnels for the Pennsylvania system, follow him not only because he is always involved in big things and they like to be also, but because he does his best by them. The only explanation why a man should want to work in the North River tunnel the way the work was done in 1890 was because the man in question had a mania for risking his life. To-day he has a fighting chance of doing his work and moving on to another attractive job.

The pressure of compressed air at 30 to 40 pounds the average at the tunnnel's heading is, of course, a danger not to be played with. In the Pennsylvania tunnels the greatest care was taken in the air locks, and coming from their work, which is the crucial time, the men were made to stew in the air chambers while the atmospheres were being slowly equalized. And still men got the "bends." Sometimes because they were physically prone to having them, but more often because, in a hurry to take their wives or sweethearts to Coney Island, they contrived to shorten their regulation stay in the transition air chambers.

To save the men from the consequences of their heedlessness Mr. Moir built another air chamber above ground, at the head of the shaft, which is manned by doctors day and night. If the sand hog is attacked with his fearful illness at the show, if an intrusive air bubble stops his circulation and menaces his life, he hails a cab or an ambulance and shouts "to the recompressor," and in that knowing east side of the city every one understands. He is placed in the iron chamber, and the atmosphere in which he has last worked is reproduced; then gradually, very gradually, the pressure is withdrawn, very slowly the atmosphere of the recompressor approaches that of the outside, and the air bubble which threatened the life of a valuable man exudes harmlessly.

This merciful invention and generous application of it has saved scores, and, indeed, hundreds of lives in the Pennsylvania tunnels, and the grateful "sandhogs," remembering their fellow-workers and their benefactor, have had one of these air chambers, which has been the salvation of so many of them, modeled in gold and presented to Mr. Moir. He likes it because it shows the way his manly men like a manly boss, but what pleases him most about the souvenir, perhaps, being a practical man and not a sentimentalist, is that the model is a true one. The crafty sand hogs saw to that, and now the great boss can compress air with a little trinket which hangs from his watch chain wherever he goes.

THE OXY-ACETYLENE BURNER CUTS DOWN A BRIDGE

The oxy-acetylene burner used for cutting steel plates is essentially like that used for welding, except that it has an additional oxygen supply pipe. The principle is to first heat the steel to a very high temperature with the oxy-acetylene flame and then by directing a stream of pure oxygen on the hot plate to start the independent burning of the metal itself—autogenous burning. The method is simple and easy and the cut is said to be as sharp as if made with a saw. It is in actual commercial use in Europe. A transatlantic steamer had run in night time against an iron bridge which crosses the channel between the Bassin d'Eure and the Bassin Bellot in France. The bridge, which had a length of 50 meters, (164 feet) a breadth of 7 meters and a weight of 250 tons, was thereby entirely deformed and distorted so that no ships could pass the channel. Since several steamers wanted to leave the next day, it was soon found that it would be necessary to take the bridge down. This was tried with sawing, but it was found that this would take at least a week. Then the oxy-acetylene method was applied and the job was completely finished within 20 hours.

CORLISS VALVES ON AIR COMPRESSORS

Simple Directions for Setting Them, with Diagrams Illustrating the Two Principal Forms of Corliss Air Valve Drive, Plain and Swing Plate.

By H. V. Conrad.

Theoretically the Corliss inlet valve of an air-compressing cylinder should open the port instantly at the beginning of the stroke of the air-cylinder piston, and also close instantly at the end of the stroke, presenting the widest opening of the port at mid-stroke when the piston is traveling at its greatest speed. It is impracticable, however, to build such cylinders without end clearance, made up of the clearance between the piston and cylinder-head, plus that of the air ports under the valves, therefore, the percentage of this clearance determines the point at which the inlet valve should open.

The compressed air contained in the clearance space at the end of the stroke should be allowed to re-expand to the intake pressure as the piston recedes, before the inlet port is opened to admit new air. This takes place automatically, when spring poppet-inlet valves are used, which do not open until the pressure in the cylinder is drawn down below the outside pressure, but the Corliss valve having a fixed travel must be adjusted to meet this condition.

THE CLEARANCE.

Corliss inlet valves are most frequently found in compound air cylinders (also those for low air pressure), where two and one-half or three total compressions occur in each cylinder, and we will assume for illustration the compound air cylinders for 100 pounds terminal air pressure. In this case, with the cylinders properly proportioned, there will be about 2.8 compression in each cylinder, or 26 pounds gage in the low-pressure cylinder. Assume that the end clearance is equal to 1½ per cent. of stroke filled with air at 26 pounds gage; to re-expand this air to atmosphere, or the intake pressure, the volume must be 1.5×2.8=4.2 per cent. of stroke, from which deduct the original clearancee of 1½ per cent., leaving 2.7 per cent. of the stroke that the piston must travel before the valve opens; see Fig. 1.

If the data are not at hand, nor procurable, for making the above calculation for any particular case, the valve setting must be adjusted from indicator diagrams taken from the first approximate setting. The accompanying diagrams represent two forms of valve drive; as the straight or plain drive wherein the valves rotate equidistant either side of a center line that corresponds with the center of the eccentric travel, and the swing-plate drive where the valves rotate through a greater arc during the open period than during the closed period of their travel.

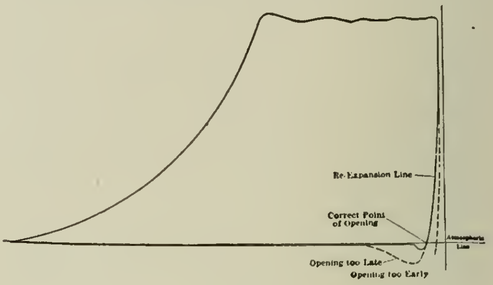


FIG. 1.

THE PLAIN DRIVE

Referring to Fig. 2, which is a plain drive, the crank-end valve will open the port during the stroke from *B* to *C* and will close it from *C* through *A* to *B*. The head-end valve will open the port during the stroke from *D* to *A* and close it from *A* through *B* to *D*.

Having determined by actual calculation of the end clearance the length of travel the piston should make before the valve should open, which, say, is equivalent to the crank-pin travel from *A* to *B*, determined the midpoint between *A* and *B*, that is, at *X*. Proceed to set the crank-end valve, first by placing the crank-pin at *X* and place the valve-arm in an exact vertical position. *M*, which should place the valve on more or less lap. Then adjust the length of the eccentric rod to suit these positions.

Next rotate the crank pin to *B*, which rotates the eccentric to *O*, and the valve arm to O^2, which should bring the valve line-and-line ready to open; if not, alter the length of the eccentric rod and adjust the valve so that it will come line-and-line. Then turn the crank pin to the center *C*, which rotates the eccentric to *P*, and the valve arm to P^2 at which point

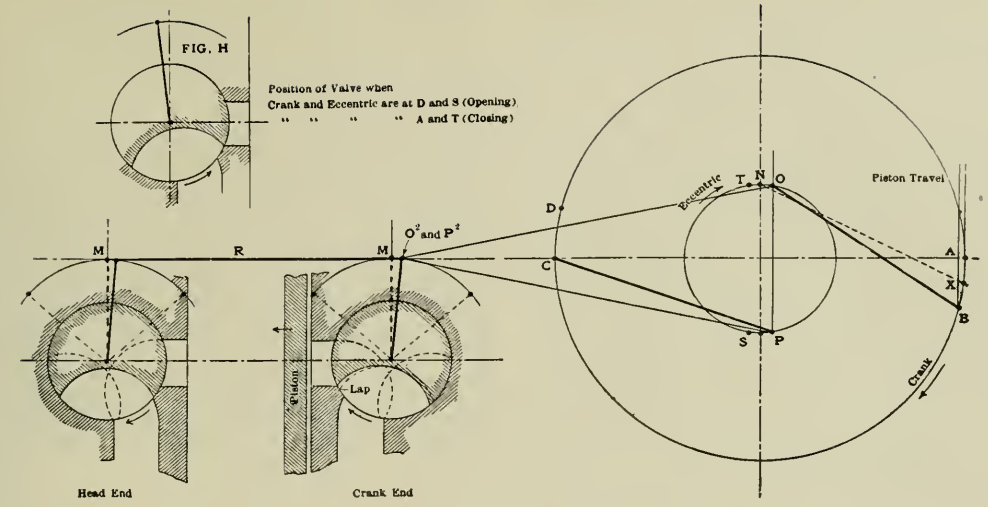


FIG. II.

the valve should be found line-and-line for closing. The valve at the head end of the cylinder is next adjusted by placing the crank pin at *D,* opposite *B,* and lengthening or shortening the valve rod *R* so that the valve stands line-and-line for opening the port, see Fig. *H.* Then turn the crank pin over to the center *A,* when the valve should be found line-and-line for closing.

If indicator diagrams taken under speed and pressure conditions show that the valve opens too late or too early at the beginning of the intake stroke, see Fig. 1, it means that in case of too late an opening the valve has too much lap and that position *B,* and consequently *X,* should be nearer *A,* which in readjusting the eccentric for this new position throws it further back. If the valve opens too early, not having enough lap, position *B,* and consequently *X,* should be farther ahead from *A,* which throws the eccentric farther ahead.

In this form of drive the eccentric follows

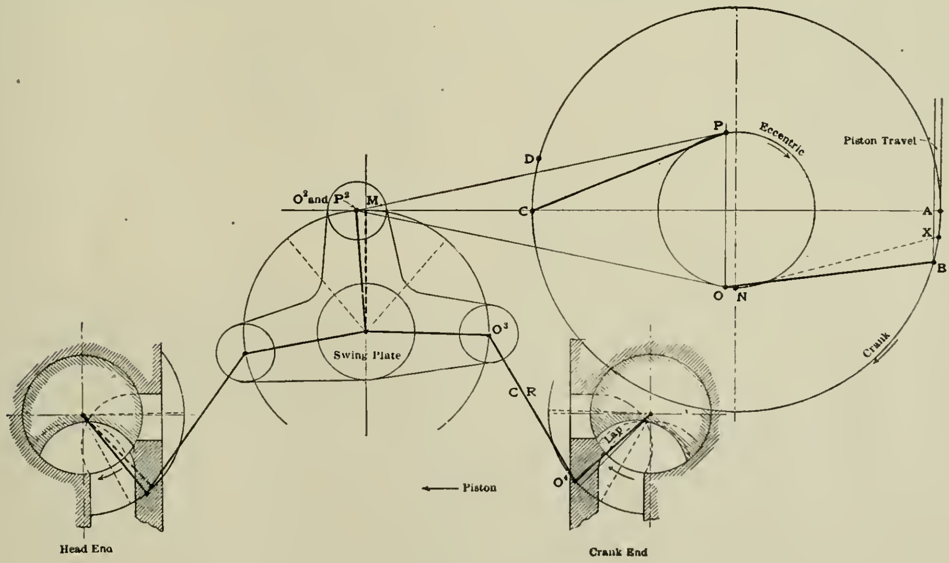


FIG III.

the crank, provided the motion is not reversed by intermediate rockers; if so reversed the eccentric leads the crank.

SWING-PLATE DRIVE.

With the swing-plate drive the valves should open and close during the same periods of stroke as in the previous case, and the letters of the diagrams correspond. Suppose the valve of the crank end is to be set first, place the crank pin at point *X*, as determined in the case of Fig. 2, and place the swing-plate on the vertical center line *M*, Fig. 3. Then place the eccentric in the lower vertical position *N*, or 90 degrees ahead of the crank pin center *A*, and adjust the length of the eccentric rod to suit these positions. Next move the crank pin to the position *B*, which rotates the eccentric to *O* and the swing-plate to O^2. The crank end valve should be placed line-and-line for opening the port, at O^4, by adjusting the length of the valve rod *CR*. Then rotate the crank pin to the centre *C*, which rotates the eccentric to *P* and brings the swing-plate back to P^2, where the valve should be line-and-line for closing.

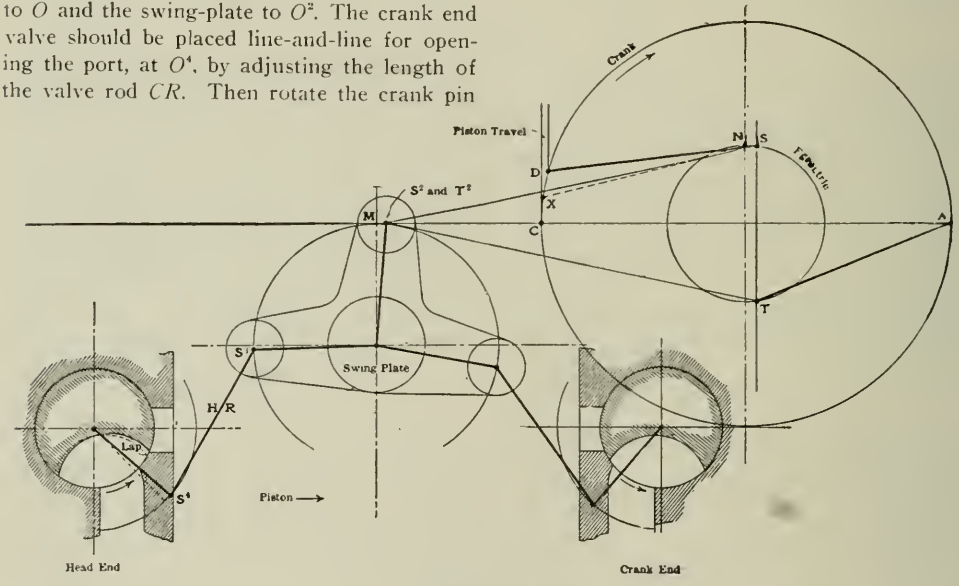


FIG. IV.

The valve of the head end of the cylinder should next be adjusted. Place the crank pin at position *D*, Fig. 4, diagonally opposite *B*. which rotates the eccentric to *T* and the swing-plate to S^2. Then place the valve in the position S^4, line-and-line for opening, by adjusting the length of the valve rod *H R*. Next rotate the crank pin to the end of the stroke *A*, which rotates the eccentric to *I* and the swing-plate to T^2, at which point the valve should be line-and-line for closing. If indicator diagrams show that the valves open too late or too early, the correct point of opening should be arrived at as in the case of the straight drive.

In the swing-plate drive illustrated, the eccentric leads the crank unless reversed by intermediate rockers in the valve gear. The diagrams are not drawn to scale, nor the details in exact relative positions to each other, but they illustrate the two principal forms of Corliss air valve drive without taking into account the many various arrangements of detail to be found in use.

In compound compression the setting of the inlet valves of the high pressure cylinder is carried out on the foregoing basis.

The Cassier Magazine Company announces the removal of its New York offices from No. 3 West 29th St., to No. 12 West 31st St., to which latter address all communications should hereafter be sent. The new home of Cassier's Magazine is in the office building just erected on the site of the former house of the American Society of Mechanical Engineers, a location especially convenient of access from the new railroad terminals and easily reached by the various systems of local transport.

COMPARISON OF HAND AND MACHINE EFFICINCIES

OLD AND NEW METHODS IN PANAMA CANAL WORK.

D. W. Bolich, Division Engineer, Culebra Division, Canal Zone, gives in *The Canal Record* an interesting statement of certain work done and of the comparative cost, especially in manual labor, under the French engineers years ago and under the engineers at present in charge of the work. The comparisons do not involve nationality, but rather the old and the new or hand and machine methods. The notes as to present work are based upon the work accomplished in Culebra Cut during the final month of the last dry season.

STEAM SHOVELS.

There are sixty steam shovels some of 75 tons and some of 95 tons, the 70 ton shovels having 2 1-2 and 3 1-2 cubic yard buckets and the 95-ton 5 cubic yards. We have had shovels that loaded as much as 2,175 cubic yards of mixed rock and dirt (about half and half) in one day of eight hours. Of the 44 shovels which we averaged daily at work during the month of March (1907), each averaged 18,600 cubic yards for the month, this representing for a day for each shovel 744 cubic yards. Say that a good man would load 6 cubic yards in eight hours, this would equal the work done by 124 men, and the work done by 44 shovels, in loading only, would represented the work of 5,456 laborers, as against 298 laborers used as pit men in moving up the shovel and clearing track and firemen, the two white men on each shovel (engineer and craneman) about equaling the number of white foremen necessarly to handle 5,457 laborers.

BLASTING.

Another point that should be remembered in using the steam shovel as a means of excavating the cut, is the question of drilling and blasting the ground into such sizes or weights, as that men could load same on cars. A man will generally handle a rock weighing 150 to 200 pounds, or 1 1-2 to 2 cubic feet; a steam shovel will handle rock weighing 21,000 pounds, or 189 cubic feet (taking weight of rock at only 3,000 pounds to the cubic yard, which is very low).

Comparing with men loading, the fact that we would have to do fully twice, if not three times as much drilling as for shovels must be considered, and also that while we can, for a steam shovel, blast a cubic yard of material with one-third pound of explosives, for men, we would use a pound of explosive for a cubic yard of material loaded. Therefore, on our drilling and blasting, instead of 700 to 800 men, it would take 2,100 to 2,400 men, and instead of using, as in the month of March, 260,000 pounds of explosives for an output of 815,270 cubic yards, it would have been necessary to use 780,000 pounds, oi more, of explosives to do this part of the excavating by hand.

SPREADERS AND TRACKTHROWERS.

On the dump ground as to tracks: These are laid by hand and do not involve the question of machinery. After the track is once laid, it becomes necessary to keep throwing it out to the edge of the dump in order to distribute more material. In throwing this track, we use a track throwing machine. This machine will throw 5,400 lineal feet (or 120 feet over a mile) of track, 9 feet in eight hours, and represents the work of 500 to 600 men in the same length of time. This machine is handled by three white men and six laborers, and as 5,400 feet of track thrown each day 9 feet on an 18-foot height of dump would take care of the daily output at this time, this machine would show, therefore, a saving in the number of laborers of from 500 to 600 men throwing by hand. The nine men operating this machine are about equal in number to the foremen that would be required to direct a gang of 500 to 600 men.

In unloading material from cars with plows and unloaders, a material gain is made in the less number of laborers needed to take care of the output. The best record that has been made here by a single unloader has been 16 trains in eight hours, or 5,000 cubic yards. This shows that 7 unloaders and plows would take care of our daily output as to the month of March, and would mean that 28 white men and 42 laborers and firemen with the machines, could unload 32,000 cubic yards a day. Estimating that a man would unload 12 cubic yards a day of eight hours by hand (as against 6 cubic yards loading) it would mean that by old methods, or unloading by hand, it would take 2,660 laborers with necessary white foremen (say 100), as against machines with 28 white men and 43 laborers and foremen. This has actually been accomplished by one machine. But, even assuming that 20 machines were used, the comparison would show that the machines with 120 laborers would accomplish as much in unloading as 2,660 laborers by hand, the white men on the machines being about equal in number to the white foremen handling the laborers.

After material has been plowed off the cars it is then pushed away from the track by spreaders, which throw the material out from the track on which cars have been plowed, from 9 to 12 feet, and cut down the new material to the bottom of the ties of the track on which the spreader is working.

This machine, in a way, does not save handling all the material by hand, as, naturally, with track thrown out to edge of dumps most of the material runs down side or slope of dump, but it does save in the cost by not making it necessary to throw the track to the edge of the dump every cubic yard per foot of the length of the dump and thereby stopping the use of the dump every hour or so; else the material plowed off cars would have to be handled by hand.

This machine really expedites the progress of the work, but to accomplish this by hand would involve, without doubt, the use of 3,000 laborers as against eight machines, 16 white men and 24 laborers and firemen.

AS TO HANDLING OF MATERIAL.

Hauling the material from the shovels, or the starting point of the output, to the disposal, or the dumping of same, brings in the transportation or train service, and the modern engine and car as compared with the engine and car of 25 years ago.

The engines as used by the French companies, and which have been rebuilt by us (i. e., the standard type used by them), will haul 10 or 12 of the old French dump cars, which hold (as we estimate in our reports) 4 cubic yards, or would represent a train carrying 48 cubic yards of material.

Our engines haul 20 Western dump cars of 12 cubic yards each or 240 cubic yards of material per train, or 17 flat cars of 18 cubic yards each, or 306 cubic yards material; or to haul our present output of 32,000 cubic yards daily, it would take 666 French trains, as against 133 trains of Western dumps, or 104 trains of flat cars of our American equipment.

NEW AND OLD METHODS COMPARED.

As a comparison of methods used by the French (which, of course, were the methods in vogue twenty-five years ago, on construction work, even in the United States, or you could say hand work only), with the modern machinery and 7,000 men, superintendents, foremen, timekeepers, laborers, etc., all told, on the Culebra Cut, we are getting out and disposing of, as to month of March, 815,270 cubic yards as against 282,528 cubic yards by the French at the height of their operation when they took that amount out of Culebra Cut in one month with 16,000 to 18,000 (record not quite clear) laborers alone, not including their superintendents, foremen, etc., although probably of this number of laborers 50 per cent. was the efficient working force, or 9,000 laborers. The results per month would be per laborer 32 cubic yards each, under the French as the output of every man connected with the Culebra Cut of 116 cubic yards each per month under the Americans.

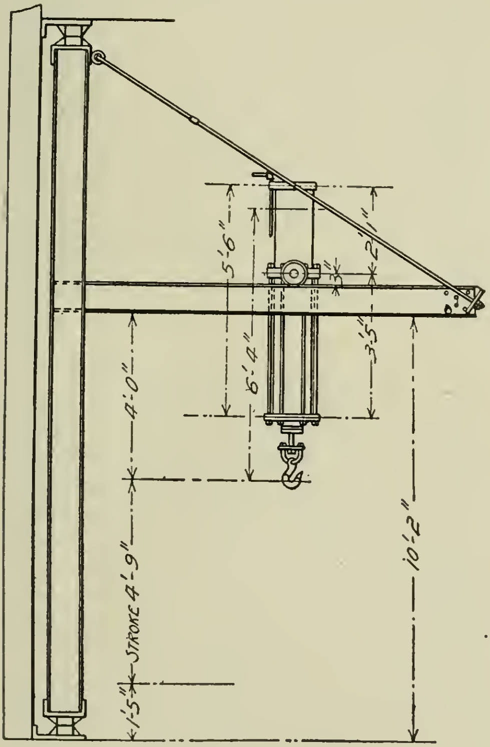
It should be considered here that our figures are from actual results and not from what the working plant should be. It is not considered at this time that the steam shovels are working more than 60 per cent. of the time they should, on account of all the rolling stock necessary to keep the shovels goceived, though ordered.

To get the full output, would not involve any material increase in the number of laborers now working, as it is considered that the maximum number of laborers required to get the daily output to the amount necessary to complete the Culebra Cut in five years, has very nearly been obtained.

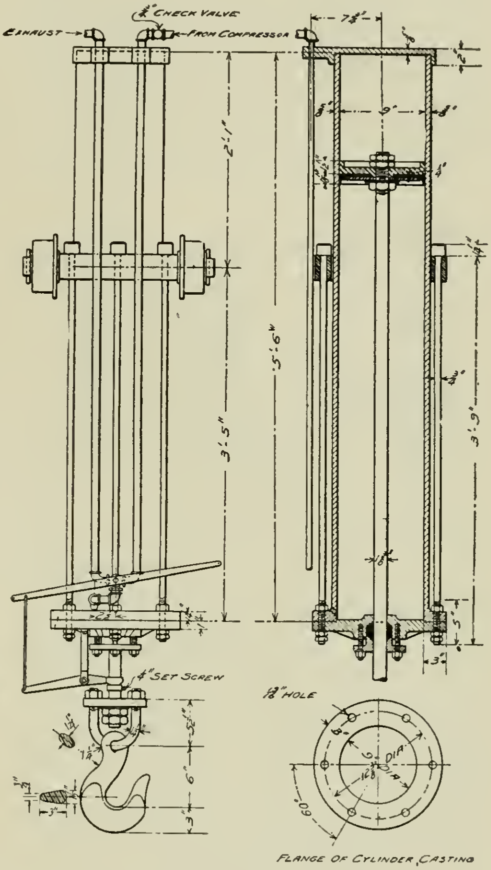
Grass along the track and right of way of the Northern Texas Traction Company for thirty-five miles between Fort Worth and Dallas is now removed by an oil burner mounted on a flat car run slowly over the track. Crude oil is used as fuel. The outfit consists of a motor-driven air compressor, two air reservoirs, three oil reservoirs, and four burners, together with the necessary valves and fittings.

AIR HOIST JIB CRANES

The dimensional cuts on this page, adapted from the Electric Railway Review, give all the essential particulars of a series of handy air hoist jib cranes in service in the Emeryville (Cal.) shops of the Key Route and the Oakland Traction Company. These cranes are installed at the ends of pits in the shops and also near the large machine tools. Each crane supported at the top and bottom by trunnions comprises a vertical post of structural shapes which give easy radical movement. The horizontal arm is made of two light I beams between which the cylinder travels supported by a two wheel carriage. The cylinders are 9-in. diameter and the pistons have a travel of 5 ft., the usual shop pressure of 75 lbs. giving a lift of 4,500 lbs. The lift and descent is entirely controlled by a three-way cock located near the lower end of the cylinder, hand chains from the cross handle hanging down within easy reach of the operator. A set collar on the piston rod may be located to stop the hoist automatically at any point, and when at its lowest position it stops the piston before it strikes the top head.



JIB CRANE WITH AIR HOIST.

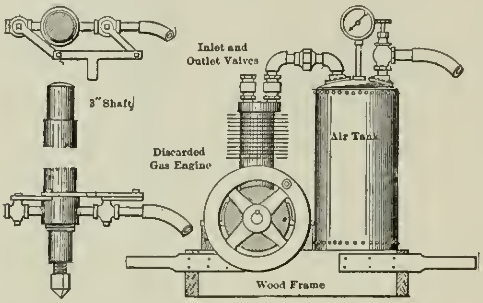


THE AIR HOIST.

An English manufacturer of carbon brushes has brought out a brush holder for turbo-generators in which compressed air is used for maintaining the brush pressure. The brush is attached to a brass piston which moves in a cylinder, the pressure upon the piston being applied through a rubber cap or bag which surrounds the end of the air supply pipe. The pressure, which is about 3 lb. per sq. in., is secured initially by a foot pump and is afterwards maintained by a weighted cylinder. Satisfactory results are said to have been secured on small turbo-generators running up to 2,500 to 3,500 r.p.m.

A HOME-MADE COMPRESSOR AND HAMMER

The sketch herewith tells us quite clearly about a home-made portable air compressor and a pneumatic jack or hammer, described by a correspondent in a recent issue of the *American Machinist.* The compressor is made from a little two cycle gas engine, in which capacity it seems to have been not much of a success. It would run like sixty until it got hot, and then it would backfire and stop. The cylinder is a piece of 3 inch pipe, one end screwed into the crank case and the other closed with a pipe cap. The radiating air coating blades are of sheet steel bored and shrunk on. As an air compressor it is of course single acting with inlet and discharge valves both in the top head or cap. In the shop the flywheel may be belted to any convenient pulley on the line shaft or elsewhere. When the rig is carried where there is no power available a handle is screwed into the wheel and it is cranked by hand. The receiver is a 10 gallon galvanized iron tank fastened onto a 2x8 inch beam close to the compressor. The air is conveyed from the tank to the hammer by a piece of garden hose.



The cylinder of the hammer is a piece of common iron pipe bored smooth. If brass pipe had been used it would not have required boring and would probably been cheaper and better. The cylinder in this case was 3 by 15 inch and the plunger a solid piece of 3 inch shafting 18 inches long with a cup leather packing on the end. The hammer of course is not automatic but strikes a blow every time the pressure cock is opened, this movement closing the discharge cock, and *vice versa.*

We are assured that this simple arrangement is not to be dispised. It has been used for driving back crown sheets, as a holding-on bar and for driving stay bolts. It could be used to good advantage even in an up-to-date shop for driving in close places. Good sized bulges in small fire boxes have been driven back by it. This was done without heating, as the fireboxes were only large enough for a small man with the hammer.

FLORISTS USE COMPRESSED AIR

At the greenhouses of Poehlman Brothers Company, near Chicago, said to be the best equipped if not also the largest in America, with 22 houses of American Beauty roses ranging from 185 to 400 feet in length, a novel method of cleaning the rose benches has been put into practice. Compressed air is piped along the center walk and connections are made with the benches. An operator with hose and nozzle can start at one end of a run and blow all the dead leaves from the stock and loose straw from the manure, collecting all at the end of the run by a curtain of canvas stretched at the point beyond which it is not desired to go. A very little time is required to do the work, and the appearance of the houses is wonderfully improved. At this estableshment the air lift also is in operation at various points.

CHICAGO WATER LOOP

The following was given to the daily press of the country on the *First* of April. Whether the date had anything to do with it we are not informed. A twelve-million dollar water loop to encircle the business part of Chicago, is proposed by Frederic A. Delano of the Harbor Commission. The loop, if constructed, is to consist of a canal 300 feet wide, extending from Lake Michigan to the south fork of the Chicago River, at about Twenty-sixth street. This would form a complete water loop wide enough, and to be made deep enough, to accommodate the largest ships of commerce. Mr. Delano points out that vessels could enter the busiest centre of the city at the north gateway, load or unload, and proceed out to the lake again by the southern door, which is to be by an extension of the artificial waterway from the south fork eastward through Twenty-second or Twenty-sixth street to the lake.

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AND EVERYTHING PNEUMATIC
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DISTRIBUTING THE COST OF DISTRIBUTED BENEFITS

The original New York Subway, since the recent opening of the line to Atlantic Avenue, Brooklyn, may now be looked upon as a completed system of popular transport, and Compressed Air, representing the principal and most responsible physical agent in its construction, cannot well avoid some notice of this important consummation. In the course of time—and not a long time—there will naturally be additional branches from and extensions of the present lines, and close connections with other lines inevitably to be built; but as it is now the Subway must be considered a very complete system, with some of the features of it highly satisfactory, but with one special cause for dissatisfaction and regret. The Subway connects the three principal boroughs of Greater New York, bringing them practically much closer together and in more intimate and sympathetic touch. Its two termini, or, more correctly, three, are in the most central and accessible locations in the Bronx and in Brooklyn, while Manhattan is traversed near its backbone from end to end.

Next to the convenience and comfort of the numerous passengers, and the speed with which they are carried, the marvel to the individual is the cheapness of it. Two cents a mile is the current idea of the long haul steam railroads, while in the Subway, for whoever chooses, it is two or three miles for a cent. This cheapness of transportation, considering the distances traversed, is characteristic of all the systems of popular conveyance in New York. On some of the surface lines it is possible to ride for a single fare until one is, or should be, ashamed to ride any further, and on the elevated lines any one who is sufficiently informed may ride all day without challenge. Of course not many take advantage of this opportunity or could find any advantage to themselves in doing so, and the company is thus automatically protected from unlimited over-riding.

The complaint of overcrowding, which is always to be heard, and on practically all lines at some times of the day, would seem to be the unavoidable accompaniment of the low fares, the profits, whatever there may be, being all contributed by the strap-hangers. It is practically certain that no line in New York could pay expenses if it gave everybody a seat at all hours of the day.

The benefits of urban and of interurban transportation are not all upon the individual passengers actually carried. Each one rides for a purpose other than the ride itself. The majority are workers of some class and are going to or from the places of their industrial activities. The workers of the trading, supervising or employing classes are working for others constantly and producing results to be shared by the many. The workers of the wage earning classes also are being transported for the benefit of their employers and of their employer's customers. So the many who seek only amusement and recreation, when they reach the places where these desirable are dispensed usually pay quite liberally for them and their visits leave large profits where they go.

The Subway may be considered as for the time reasonably adequate for its local traffic in the business and residence portions of Manhattan, but this is its minor function and also is largely provided for by other systems. Its real purpose and promise of relief was in its outreach beyond the congested areas, and for this its entire inadequacy is evident enough and must be emphasized by vast discomfort and inconvenience during the present summer. At the northern extremities of the system Van Cortlandt Park will be reached by one branch as Bronx Park with the magnificent "zoo" is already reached by the other, and the rush to these will be profitable to the management, so far as the crowding and overcrowding of trains bring the profit; but these profits will be much restricted by the insuffīcent capacity for handling and carrying the crowds.

But the most disappointing inadequacy of the Subway will be realized at the southern terminus of the line, Atlantic Avenue, Brooklyn. Here is effected the most intimate and perfect connection of all Manhattan and of all beyond it with the Long Island Railroad and all the magnificent and unlimited possibilities of suburban residence thereby afforded. Besides that, at this same point is now the best, shortest, cheapest and most available route to the popular seaside resorts: Coney, Brighton, Manhattan, Rockaway, Far Rockaway, Long Beach.

The incapacity of the Subway and its tunnels for conveying the inevitable crowds is self evident and much disappointment and dissatisfaction must develop. Other lines which are planned will in time help the matter, but precisely where the present line is located is the best place for a large increase of capacity. This will entail of course large expenses, most of which would be covered by the great increase of receipts, but whether the additions would "pay" at once or later is not the only question, because there would be so many benefitted besides these actually carried, and these beneficiaries should in some way share the cost.

THE ELECTRIC AIR DRILL PARADOX

"At the last meeting of the Chemical, Metallurgical and Mining Society, Mr. T. Lane Carter made some interesting remarks in regard to electric rock drills—of which the Temple-Ingersoll type, it will be remembered, is the best known. Mr. Lane Carter admits that if an efficient electric drill could be found it would be a great blessing, but he does not believe there is much scope for a drill which is supplied by air compressed in the mine by an electric machine near by. The only places where such machines would be successful are in countries like the Western States or Italy, where there is enormous water power, and where electricity is very cheap. Until the Victoria Falls electricity gets here, he is of opinion that power will not be cheap enough on the Rand for such machines."

The above, from the latest-to-hand copy of the *South African Mining Journal,* is a good illustration of the ease and completeness with which the Electric Air Drill is misunderstood. The drill is not in the least an electric drill, and it is in no way related to the air operated drill as heretofore known. The little portable apparatus accompanying the drill proper is a pulsator, and is as much a rarifier of the air as it is a compressor, and the power required for equal work instead of being greater is only one-third to one-fourth, at the power house, of that required for any of the drills of the more familiar types. The drill is especially desirable where power is dear, instead of cheap.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The semi-annual meeting of The American Society of Mechanical Engineers will be held in Detroit, Michigan, June 23-26. An entire session will be devoted to papers on the conveying of materials, when hoisting and conveying machinery, including belt conveyers, the use of conveying machinery in cement plants, etc., will be discussed. Among other subjects which will be taken up by professional papers are, "Clutches," with special reference to automobile clutches, by Henry Souther: "Some Pitot Tube Studies" by Prof. W. B. Gregory, of Tulane University, New Orleans, La., and Prof. E. W. Schroder, of Cornell University; "Thermal Properties of Superheated Steam," by Prof. R. C. H. Heck, of Lehigh University; "Horse Power, Friction Losses and Efficiencies of Gas and Oil Engines," by Prof. Lionel S. Marks, of Harvard University; "A Journal Friction Measuring Machine," by Henry Hess, of Philedelphia; "A Simple Method of Cleaning Gas Conduits," by W. D. Mount; "A Rational Method of Checking Conical Pistons for Stress," by Prof. G. H. Shepard, of Syracuse, University; and "The By-Product Coke Oven," by W. H. Blauvelt.

A lecture on "Contributions of Photography to our Knowledge of Stellar Evolutions" will be delivered by Prof. John A. Brashear, of Allegheny, Pa. The usual receptions will be held and excursions will be made to manufacturing plants, the ship building yards and various points of interest in and around Detroit. Among the excursions planned is one to the University of Michigan, at Ann Arbor. The Gas Power Section of the Society will hold a session, and the Society for the Promotion of Engineering Education and the Society of Automobile Engineers will hold a meeting in Detroit at the same time.

The following will be read with interest in connection with the article by Mr. Rix which appears in the present issue:

Compressed air has become so important a form of motive power that any elucidation of the principles involved is bound to be interesting. And no one is better fitted to expound this subject than Mr. Edward A. Rix. It is 30 years since he and his partners, W. H. and John B. Reynolds, brought the Ingersoll drill to the aid of Adolf Sutro in the making of the great adit that drained the Comstock lode, and it is 30 years since Mr. Rix took the same drill to the Idaho mine at Grass Valley and replaced the old Burleigh machnes, which weighed 600 pounds apiece, as against, say, 275 pounds for a drill of equal utility to-day. The Burleigh had just made a record in the Hoosac tunnel, a railway bore in Massachusetts, where this first machine-drill was invented about 1872.—*Mining and Scientific Press,* San Francisco.

QUESTIONS AND ANSWERS

T. D. P., Winnipeg, Manitoba. *Q.:* With electric current supplied at $12.50 per horse-power per annum—24 hours service—what would it cost to compress 10,000 cubic feet of free air per minute to 50 lbs. gage, assuming the barometric pressure to be normal, or 14.7 lbs? *A.:* The theoretical cost of compressing, adiabatically, 1 cubic foot of free air per minute to 50 lbs. gage, is 0.11952 horse--power and therefore the cost per 10,000 cu. ft. would be 1195.2 horse-power. If to this we add 25 per cent. for all losses in the compressor itself, friction, leakage, etc., the horse-power to be actually delivered to the compressor, and not taking into account any of the preliminary losses, will be 1494, which, at $12.50 per horse-power, amounts to $186,750.

E. R. S., San Francisco. *Q.* In your March issue you state the rule of the A. L. A. M., for estimating the horse power of gasolene engines to be the square of the cylinder diameter in inches divided by 2.5. Is there not some factor omitted? We would suppose that the length of the stroke would have much to do with the power. *A*: The rule was, we believe, printed correctly. It is of course only a rough-and-ready rule, better as a suggestion to guess by than a guide for accurate computation. The length of stroke would not cut much of a figure because the shorter stroke would imply the higher rotation and *vice versa.* Gasolene engines, especially in automobiles, are run at all sorts of speeds, and whatever the nominal horse power, by the above or any other rule, the actual might be double or one-half or almost anything. The presumption would generally hold that the larger the cylinder diameter the higher would be the horse power. Instead of dividing by 2.5 we would multiply by its reciprocal, 0.4, giving the same result.

P. P., Helena, Montana. *Q.:* I wish to secure some data on the lifting power of compressed air of various degrees of compression, the object being to lift from 2 to 4 cu. ft. of water per second to a height of 200 feet—not necessarily a vertical lift; a favorable incline can be had—for purposes of irrigation. Hydraulic rams to do this would be too expensive and to secure compressed air by compressors would also be too expensive. The plan would have to be along the lines worked out by Mr. W. O. Webber on the Maine Coast. Ditch construction is not practical, but it is practical to secure considerable fall for the purpose of compressing air on the plan referred to.

A.: There is no way ever devised which will dodge the expense in a case like this. It should be noted that in the description of the Webber tidal air compressor in our March issue the estimated cost of the construction was $100 per horse-power. The Taylor system which uses falling water for compressing air also costs quite an amount for the necessary excavation, piping, etc, this varying largely with the location and other conditions. The theoretical power required in the case cited by our correspondent would be: 4 cu. ft. per sec. x 60 sec. x 62.5 lbs. per cu. ft. x 200 ft lift÷.33000=90.9, say 91, horse-power. Allowing for all losses, both with the water and the air, probably nearly double this power would be required at the beginning of the series. As to the best plan in this specific case we are unable to advise without more knowledge of the situation.

PNEUMATIC RIVETING HAMMERS IN BOILER WORK

The following question, with answers from two boiler making firms, appeared in *The Boilermaker:*

Q.—Can you give me an idea of the character of work done with pneumatic riveting hammers driving ⅞-inch rivets in ½-inch sheets in the shells of steam boilers carrying 125 pounds pressure? Do they fill the holes and make good steamtight work? If so, what size hammers are generally used for this size of rivet. We have tried a 6-inch stroke hammer, but it did not fill the holes properly.

H. A. F.

A.—The work you describe is done every day and very satisfactorily, too, in many shops, but a 6-inch stroke hammer is not the proper size, as it will not develop sufficient power. We would recommend a hammer which has a piston diameter of 1⅛-inch by 9-inch stroke, and if operated under an air pressure of from 80 to 100 pounds per square inch, we are sure ⅞-inch rivets can be driven steam-tight.

D. P. T. Co.

If you have an air pressure of from 90 to 100 pounds per square inch, and the rivets are properly heated their entire length, using a pneumatic hammer having a piston 1 3/16-inches diameter and 8-inch stroke should make absolutely tight work, filling the holes as well as it is possible to fill them under any other system of riveting.

We note you say you have tried a 6-inch stroke hammer. While a 6-inch stroke hammer is used very extensively for structural work, we would not recommend a 6-inch stroke hammer for driving steam-tight work on rivets larger than ½ inch. You are doubtless aware that a pneumatic riveting hammer may show very satisfactory results driving rivets on structural work and yet fail to make steam-tight work on boiler work. A little experimenting will show that the degree to which the rivet is staved in the hole depends very largely upon the weight of the striking piston. While in the ordinary hand riveter for structural work the piston is 1 1/16 inches in diameter, a class of riveters with pistons 1 3/16 inches in diameter is, by virtue of the heavier piston, particularly adapted to steam-tight work. P. P. T. Co.

NEW BOOKS

Telephone Construction, Installation, Wiring, Operation and Maintenance, by W. H. Radcliffe and H. C. Cushing, Jr., The Norman W. Henley Publishing Company, New York, VIII +172 pages, 4¼ by 7 inches, 125 cuts. Price, $1.00.

This is not a learned book by and for the college professor but is for "the amateur, the wireman or the engineer who desires to establish communication between the rooms of his home office or shop; between his house and shop; between his home and the homes of his friends; or between his shop and some distant building." Everything is made plain and clear without any waste of words, and the book has no padding.

TRADE PUBLICATIONS

Light Locomotives, Tenth Edition, H. K. Porter Company, Pittsburgh, Pa. 224 uages, 6x9 inches. This handsome catalogue compares with its predecessors as the present plant of the company compares with its earlier installations. The annual capacity has increased from 20 to 400 locomotives, and since the immediately preceding edition we are assured that the progress, in the increased power and efficiency and in the quality of output has been far greater than during any similar period before. Only steam locomotives, but these in astonishing variety, are treated of in this publication and in addition there are about 80 pages of valuable tables, data and suggestive railroad information.

OILING AIR DRILLS

The following is from an article by Mr. Claude T. Rice in *The Engineering and Mining Journal.* It has the supreme merit of being readable and interesting. The matter of lubrication we believe, however, is not ignored by the builders of the drills to the extent suggested, and whoever will may properly oil his drill by means already provided, at least by the most responsible and experienced drill manufacturers.

The air drill is the most abused machine in use about mines, for it is supposed to be able to stand all kinds of rough usuage. No one seems to have any real respect for the air drill, although many discuss the merits of one machine over another. The miner, seeing a machine whose interior parts are as well finished as the interior of a steam cylinder, furnished to him without any provision for oiling, naturally forms a sort of contempt for it and decides that it can stand any treatment; therefore he acts accordingly. He hammers the machine in his rage when a hole becomes fitchered, although a little shifting of the machine on the arm or a little raising or lowering of the arm on the bar might have saved the hole. Of course such treatment of a machine is foolish, but when I hear some person ascribing high repair bills entirely to the "fool" machineman. I often wonder who is the fool; the miner, who hammers the drill with a "double-jack," or the man with the T-square in the designing room, who is spending all his time on improving the construction of the valve, the piston, the ports and other such refinements, so that he cannot find time to devise an efficient means of lubricating the machinery.

Of course the man with the T-square says that there is no use in designing a means of oiling a machine that works under such conditions; the oil, he says, will only cause dust to stick more readily to the moving parts and cause them to cut. But the air in a raise is no dustier than the air near rolls that are crushing dry ore, and no one advocates the non-lubrication of such rolls.

In present mining practice, at least in the Western camps of the United States, the air drills that are oiled six times a shift are like the dodo bird, hard to find. The machineman, as soon as he has rigged up and connected the hose, pours some oil in the valve, tells the helper to stand back, starts the machine, and blows oil all over the stope. The drill is then generally considered to be properly lubricated until noontime; after lunch the drill gets another "dose of oil," and the stope a second coat.

The oil is generally kept in a tomato can; half the oil is spilt in the stope, and the half that is used is soon heavily laden with rock particles. Sometimes a miner, more careful than his mates, will bring from home an empty syrup can. Such a can makes a good oil can, provided it is stoppered after using and provided also it is placed at blasting time in some place where it will be safe from puncture by a flying rock.

Some companies, becoming impressed with the great waste of oil, try to remedy the difficulty by furnishing an iron oil can to the miner. But as the company charges the miner 50c. for the oil can until he returns it, the miner reluctantly receives the can, for he knows sooner or later that he will lose it. Finally the can is lost and the miner spends 50c. worth of his time hunting for the can, and, in case a wrangle arises through his accusing some other miner of stealing or hiding the can, a good deal more time (and possibly some blood) is lost. The result is that by using this can, which is no better than the old syrup can, a lot of valuable time is lost in hunting for the can when it is lost. The company thinks that the miner pays for the lost can, and so he does, but the company also pays, considering the time that is lost. The trouble is not in the oil can; it is in the method of lubricating the drill. Any can (but not any bottle) that keeps dust out of the oil is good enough. The remedy is not in buying iron oil cans, but in insisting that the manufacturers devise some efficient lubricator to go with their air drills.

COMPROMISING IN MINE PIPING

In the Journal of the Transvaal Institute of Mining Engineers, Mr. E. J. Laschinger offers the following suggestions:

The considerations involved in a study of economy of air transmission in mines raises the larger question as to whether it may be advisable to modify current practice of air compression on the Rand, at least in certain cases. Would it not be better to increase the pressure of air delivered by the compressors in the case of the deep-deeps rather than go to the great extra expense of putting in very large, long air mains? There may be certain cases also where existing mains are up to the economic limit in size, and satisfactory pressures underground would be obtained more cheaply by slightly raising the pressure at the surface than by installing new and expensive mains. This is an important matter for detailed investigation. If in any part of the system the pipes are smaller than economic transmission considerations indicate, the sizes should be increased, but if that limit has been reached, the other alternative appears to offer the proper solution.

Another argument against installing rather large mains in case of mines is that the air will be delivered only at its maximum distance from the compressors toward the end of the life of the mine. During the first years the loss of pressure for the shorter lengths will be proportionately small, and if towards the end of the life of the mine the pressure loss be found to very adversely affect the working of the drills, it would probably again be more economical to slightly raise the pressure at the compressor than to have a large capital sum lying unremunerative for years. There is a tendency at present among mining men and engineers on the Rand to go in for large sizes of mains, and it may not be unnecessary to say a word of caution against going to extremes. If poor pressures obtain underground it is advisable to find out where the trouble lies, and what are the best remedies. Are the pipes leaking badly; is the main too small; or are the distributing pipes too small and badly laid; and, further, would anything be gained by raising the pressure at the compressor delivery? These four aspects of the whole question need each to be separately considered and investigated.

FOR A COMPRESSED AIR WATER SERVICE

By J. W. Lawrence.*

Out in the country, where one is away from the water mains of a city and cannot be attached, it is a source of much satisfaction to have a water supply on the premises that answers as well in many respects as the city system. To have a liberal supply of hot and cold water on tap in the house wherever you please, upstairs, downstairs, or in the cellar, to have hydrants in the barn or stock yards, similar to those in the house yards in town, from which water may be drawn for the stock, or to which a hose may be attached for washing buggies, sprinkling lawns, or other purposes, is possible under a system which has gradually been finding its way into popular favor. This system has nothing to do with the quality of the water; it is simply a system for delivering water already on the premises in well, cistern, or reservoir. It is proposed by this system to force the water through the pipes by means of compressed air. The house is piped in the same manner as if it were in the city and connected to the city mains. If it is desired that hydrants be placed about the yards, barns or outbuildings, they may be put underground in the same manner as in the city, say four feet deep, to keep them from freezing. If there are flower beds or lawns to be sprinkled, a hose may be attached to one of the hydrants at any time. The same hose may be used for fire purposes. With this system, some householders have a suitable hose bibb in the house, with a line of hose coiled and hung up ready at hand for use at any time. A windmill, gasoline engine, or some such pumping arrangement, is necessary at the start. Now, someone will say that you can have the supply thus far described by means of an elevated tank in connection with the windmill; so you can, but I believe the compressed air system much better.

An air-tight steel tank is part of the cellar of the house, and may be as large as the owner may choose to purchase. There are manufacturers who make them specially for this purpose. If a windmill is used for pumping, then the water is forced by the windmill pump through pipes into the steel tank. The pipes are put underground out of reach of frost. Some who have adopted this plan have a gasoline engine attached and ready for use, so that if the air is still, and the windmill fails to pump enough water, the gasoline engine may be used in such an emergency.

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*Professor of Mechanical Engineering, Colorado Agricultural College, Fort Collins.

Water having been pumped into the tank and the tank now being partly filled, an air-pump attached to the tank, and having a long lever worked by hand, is operated for a few minutes, and compressed air, under strong pressure, is put into the tank with the water and will force it out to the last drop at any point in the system of piping, and to a height within the forcing power of the compressed air.

There are many disadvantages in the use of the elevated tank, either outdoors or indoors; if outdoors, it gets frozen in cold weather, as will also the exposed pipe connected with it. Then there is the likelihood of dead birds, bugs, leaves, dust and rubbish getting in, and in summer the water is apt to get very warm. If indoors, the elevated tank may freeze, or perhaps leak and damage the building. The possibility of an elevated tank falling down and doing much damage is sometimes present.

The compressed air water supply is free from the objectionable features mentioned above. The water remains at a desirable temperature, winter and summer; is kept perfectly clean in the tank if delivered to it in a clean condition. The air in the tank mixes somewhat with the water and helps to aerate it, keeping it sweet and clean. There are now manufacturers who can supply these outfits suited to a small house or a great building.

AN AIR PLUG DRILL CUTS A HOLE THROUGH A CONCRETE DAM

An interesting piece of concrete cutting by means of 1½ in. flat chisels used with a compressed air plug drill was accomplished at Ithaca, N. Y., last summer, the work being described by Prof. Ernest W. Schoder, of Cornell, in a recent issue of *Engineering News.*

The problem was to cut through a ten-year old concrete dam a circular hole for a flood wasteway, at the upstream end of which it was intended to place a 60-in. sluice gate. The dam is on Fall Creek and forms the 20-acre reservoir utilized by the hydraulic laboratory and by the hydro-electric power plant of Cornell University.

The stone in the concrete is crushed shale, and the cement used a mixture of Rosendale and Portland. The concrete seemed to be soft and tough rather than hard and brittle. On account of the difficulty of drilling holes in concrete of this texture the plug and feather method was not feasible, and with the air drill the rapid action of the tool made it almost impossible to prevent it from sticking. Chipping by 1-in. flat chisels did not work satisfactorily, but the wider 1½-in. chisels seemed to be suited to the material.

The thickness of the dam is 16 ft. where the hole was cut, the invert being 2½ ft. above the rock creek bottom. The hole is 5⅓ ft. in diameter for the downstream 13 ft. of its length, and 6 ft. in diameter for the last 3 ft. near the upstream face of the dam.

The hole was cut at an average rate of exactly 1 ft. per day of nine hours, using a single drill with air at 70 lbs. pressure. Two Italian laborers alternated in holding the drill. A liberal supply of sharp chisels was kept ready so that there was no deplay. The chisels were sunk into the concrete until the repeated blows of the plug drill hammer caused a piece to break out. A few seconds to five or ten minutes were necessary to break out a piece of the concrete. As the men became accustomed to the drill they used at times a wedging method by sinking two or three chisels into the concrete along a line calculated to loosen a large piece containing perhaps ½ cu. ft. of material. This worked well, especially when the lower portion of the hole was advanced ahead of the upper portion. No water leaks were encountered. When the cutting approached within 1 ft. of the face of the dam, the reservoir was emptied through the laboratory canal.

ROCK EXCAVATION ON THE CLYDE

The deepening of the Clyde Channel to a minimum of 28 ft. below low water of the spring months was completed last year, by the removal of rock from the Elderslie reef over an area of 5½ acres. The removal of this reef was started in 1886 when the minimum depth at low water was only 14 ft. The channel was deepened to a minimum of 20 ft. by the removal of 110,000 tons of rock. In 1903 it became necessary to further increase the depth of the channel and contracts were let to Messrs. W. Hill & Co., London, for the removal of an additional ledge of 8 ft. In order to locate the work two parallel rows of poles about 300 ft. apart were set up on base lines on the bank of the river, the poles in each row being on 25-ft. centers. At first the drilling of the rock was accomplished from a barge within which was a caisson that could be lowered and raised by steam winches. The caisson was large enough to accommodate six or seven men, and contained six Ingersoll-Sergeant compressed-air rock drills. When at work in the river, the position of the barge was regulated from the bearings of the poles or stakes already described on the south bank, and its distance from the base line was measured by means of a wire rope with marks every ten feet, wound or unwound as required by a reel on the deck of the barge. Owing to the difficulty of steadying the caisson on the uneven bottom, and the limit to the lengths of the boring rods which could be used in the caisson, this mode of working was found to be unsuitable, and the contractors provided barges equipped with Ingersoll percussion drills suspended along one side of the barge by chains passing over pulleys on the top of an iron frame-work. The drills were slung in guiding frames, leaving them free to move up or down as required, but not laterally. The boring operations in the earlier stages had been carried out in patches, careful record of which was kept on charts both by the contractors and the engineer of the Clyde Trust, but later it was decided to conduct all the boring and blasting operations in belts, as had been adopted in the former contract of 1886. The belts covered a width of 15 ft. with six rows of holes in each belt. These rows were 2½ ft. apart, and the holes, which were spaced 5 ft. apart longitudinally, were opposite each other in the alternate rows. This mode of working provided a free side or face, and allowed the dredger to follow the boring barge and lift the broken rock, and clean up the surface of the next belt to be bored. For the most part the depth of rock had to be bored, blasted, and dredged in at least two breaks or depths. Under this system the work progressed much more rapidly, and, as the boring was carried to a depth of 30 ft. to 31 ft., below low water, dredging was easily accomplished to the desired depth of 28 ft. below low water. In order to be certain that the minimum depth was secured throughout, a diving bell went over the entire bottom. During the contract 38,240 holes were drilled to an average of 6 ft. The dynamite was lowered into the holes enclosed in a zinc canister. The total amount of rock removed was 340,520 long tons.—*Engineering Record.*

A SOFT TUNNEL CONTRACT

An old mining man remarked yesterday that he was once interested in a tunnel which was a very profitable venture for a friend of his in Colorado. "Railroading in my section of the country at that time," he remarked, "was primitive, but for some reason or other an urgency contract was left for the building of a tunnel in midwinter between our town or camp, as you might call it, and a point about a mile and a half distant. My partner got the contract, and he was very mysterious about it. He arranged the terms so that because of the alleged character of the work he was to get $40 a foot. I could go into details with regard to the preliminaries, but suffice it to say that within a certain specified time, unusually short, as a matter of fact, he sent for the engineer representing the company making the contract to pass on the work. It went through all right, and was approved. Now that seems all right, but as a matter of fact my friend "Gassy," as he was called, had built a tunnel through a snow mountain, put in timbers to support the weight of the snow, covered the exterior snow with dirt and mud, and decamped with the check which the fool company gave him.—*New York Times.*

AERIAL NAVIGATION TERMS

The following terms have been adopted and authorized by the Permanent Aeronautic Commission:

Any machine without a gas vessel or bag is to be called an "Aeronef," and this type is further to be divided into three sub-divisions, called Helicopters, Aeroplanes, and Orthopters. The first is an aeronef relying on one or more propellers for its suspension and progress through the air; the second is an aeronef in which suspension in the air is more particularly assured by one or more planes, and the third is an aeronef sustained and propelled by beating wings. The term aviator is to be employed as defining the operator of any of these types. Aeronaut will be applied only to the pilot of an aerostat or aeronat. The aerostat is a common balloon, floating along with the wind, and the areonat is a dirigible balloon.

NOTES

It's just as we have said time and again. Cutting the price never increases the demand by even the most insignificant fraction. That is all the more reason why a short demand should be supplied at a good round profit. *Rock Products.*

The H. W. Johns-Manville Company, fireproofing and non-conducting materials and electrical supplies, will open a new branch in Detroit, 72 Jefferson Ave., under the management of Mr. Willard K. Bush, formerly of the Milwaukee branch. A complete stock of goods will be carried.

The traction power used in anthracite mines depends directly upon the condition of the haulage roads. In a certain mine where mules hauled the coal the cost of transportation was from 9 to 11 cents per net ton mile. In most mines where compressed air locomotives are used and the grades are not too heavy the cost of haulage per ton mile does not often exceed 3.5 cents.

The two hundred and twenty-fifth anniversary of the founding of Philadelphia is to be celebrated in October. The city has 15,887 separate manufacturing establishments costing $476,500,000. The employes number 246,445, earning annually $112,000,000 in wages. The raw materials cost $327,000,000 and the value of the annual product is $603,500,000. There is a jobbing and wholesale trade of $500,000,000 annually.

The growth of the acetylene industry and the safety with which the gas may now be used has led to a modification of the insurance rules relating to it. Hitherto the rules formulated by the National Board of Fire Underwriters prohibit the installation of an acetylene generator in an insured building. At a recent meeting, however, the Board, after considering various reports on the condition of the acetylene industry decided to strike out from its rules such words as prohibited inside installation of acetylene generators, and substitute the following: "Generators, especially in closely built-up districts, should preferably be placed outside of insured buildings in generator houses constructed and located in compliance with Rule 9."

The Chicago Railways Company, which owns all of the North Side and West Side street railways in the city of Chicago, has just awarded a contract to the National Brake and Electric Company, Milwaukee, Wis., to furnish all of the air-brake apparatus for the 1,200 new cars, which, in accordance with the traction ordinance, it will purchase and place in service within the next three years. The company expects to put about 550 new cars into service this summer, orders for 400 cars having already been placed with the car builders. This contract, it is believed, covers a larger number of air brakes than has ever before been contracted for by any electric-railway company.

In a recent discussion before the Societé de l'Industrié Mineralé, M. Reumaux describes his experience with drill bits. Most of the French bits have six-pointed faces, while certain American bits have eight points. His tests have led him to adopt the eight-pointed bit. While the cutting face of the eight-point bit is necessarily larger, involving thereby the drilling of larger holes, the consumption of steel is much less, and the rate of advance is no slower than with the six-pointed bit. Referring to the sharpening of star-faced bits, Mr. Roumeux objects to the use of the swage furnished by the drill makers. He maintains that, while the swage affords a rapid method of forming the bit face, the cutting edges are neither sharp nor durable, and he advocates a return to hand dressing in order to get better results from drills.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

APRIL 7.

883,696. HYDRAULIC AIR AID GAS COMPRESSOR. GEORGGE P. CARROLL, Bridgeport. Conn.

883,730. DRILL. John F. Mitchell, Topeka. Kan.

883,814. AIR-BRAKE HOSE-COUPLING. Joseph E. LaRocque, Nominingue, Quebec, Canada.

883,858. THRUST BORING - MACHINE. Charles Christiansen, Gelsenkirchen, Germany.

A boring machine provided with a cylinder, an inclosed piston, a pair of compressed air inlet ducts communicating with opposite ends of the cylinder, a flap valve fulcrumed at its centre of gravity and controlling both of said ducts, a pair of exhaust ports in the cylinder adapted to be alternately uncovered by the piston, and a boring bit operable by said piston, substantially as specified.

883,888. AIR OR GAS COMPRESSOR SYSTEM. Huldreich Keller, Berlin, Germany.

883,918. AIR-BRAKE SYSTEM. Ulysses S. Smith, Sacramento, Cal.

883,928. VALVE FOR AIR-COMPRESSORS. Asa F. Batchelder, Schenectady, N. Y.

883,936. HYDRAULIC AIR-COMPRESSOR. Joseph H. Champ, Cleveland, Ohio.

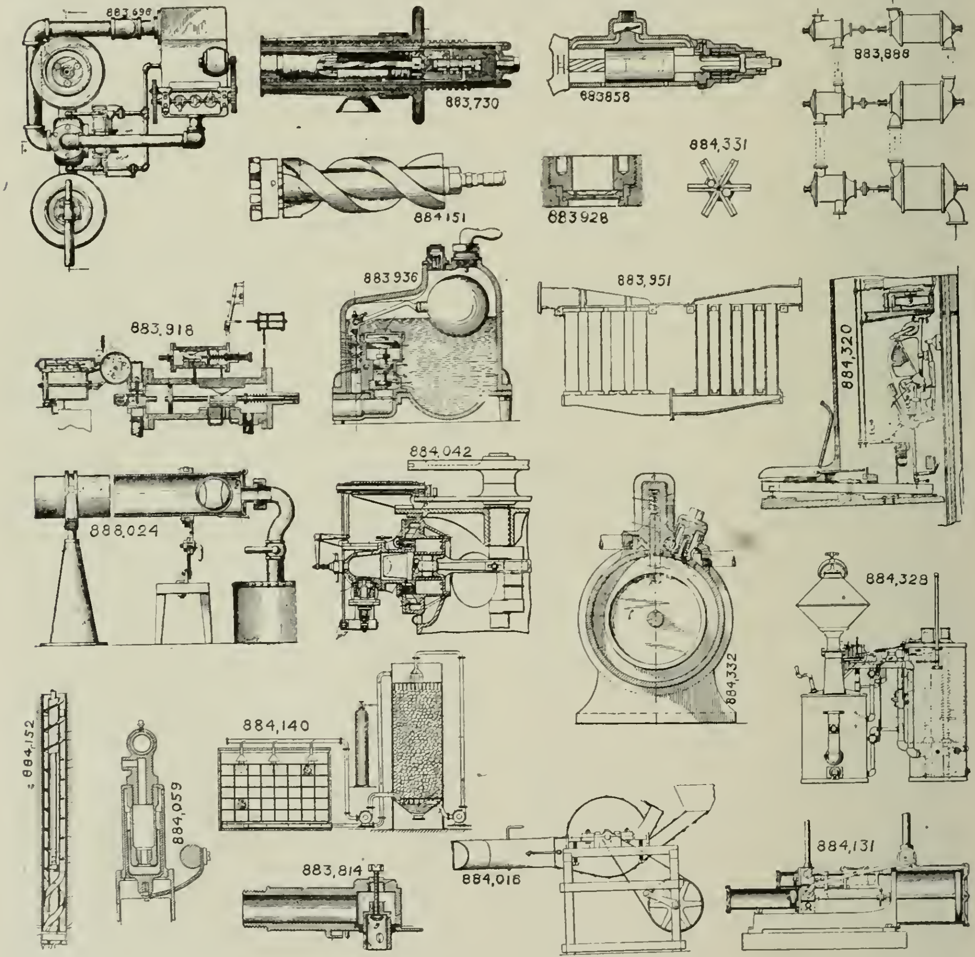
883,951. APPARATUS FOR HEATING AIR. Francis W. Green, Wakefield, England.

884,016. PNEUMATIC CONVEYER. Clarence L. Groves, Hartford City, Ind.

884,024. MECHANICAL BALL-THROWER. Robert H. Lake, Washington, D. C.

884,042. MEANS FOR PRODUCING MOTIVE FLUID FROM THE COMBUSTION OF FUEL. William J. Benshaw, Newcastle, England.

1. An apparatus for generating a motive fluid to be used expansively in a separate motor or motors consisting of a series of cylinders arranged around a common crank shaft in which cylinders moist air is compressed, a reservoir adapted to receive the compressed air from all the compression cylinders, a series of combustion cylinders also arranged around said crank in which oil and air or other combustible is burned and into which the compressed air from said reservoir passes for the purpose of extracting therefrom the heat due to combustion, said cylinders being provided with pistons and inlets, outlets, pasages and valves by means of which the oil and air or other combustible, the air to be compressed and the compressed air are admitted into the two series of cylinders and the compressed air conducted from the compression cylinders into the reservoir and from



Pneumatic Patents April 7.

the reservoir into the combustion cylinders, mixed with the products of combustion and passed into a pipe or trunk common to all the combustion cylinders, from which the mixture may be drawn off as required substantially as described herein.

884,049. PNEUMATIC HOLDER FOR COMMUTATOR-BRUSHES. Charles W. Spiers, Battersea, London, England.

884,131. MOTOR-DRIVEN EXHAUSTER AND COMPRESSOR. Melvin D. Compton, New York, N. Y.

884,140. PROCESS OF KEEPING AQUATIC ANIMALS ALIVE DURING THE TRANSPORTATION. George Erlwein, Berlin, and Ernst Marquart, Charlottenburg, Germany.

1. The method of keeping aquatic animals alive during transportation, which consists in surrounding them with a moisture-retaining packing and supplying a moisture laden oxygen-containing gas .

884,151. PNEUMATIC HAMMER. Martin Hardsogg, Ottuumwa, Iowa.

884,152. PNEUMATIC HAMMER. Martin Hardsogg Ottumwa, Iowa.

884,320. Manually and PNEUMATICALLY OPERATED PIANO. John W. Davis, Pulaska, Tenn.,

884,328. ACETYLENE-GENERATOR. Nelson Goodyear, New York, N. Y.

884,331. PNEUMATIC AND OTHER DRILLS. Martin Hardsogg, Ottumwa, Iowa.

884,332. COMPRESSOR. Bert E. Hill, Pittsburg, Kans.

APRIL 14.

884,364. COMPRESSED-AIR BRAKE. Alfred Chanderson, Jette St. Pierre, Belgium.

884,419. STONEWORKING-TOOL. Charles B. Richards, Cleveland, Ohio.

884,432. AEROPLANE. Melvin Vaniman, Genevilliers, France.

884,522. APPARATUS FOR AUTOMATICALLY DISCHARGING LIQUIDS. Albert Priestman, Philadelphia, Pa.

884,548. FLUID-ACTUATED VISE. Thomas F. Warwick, Metter, Ga.

884,694. AIR-BRAKE. William A. Weant, Mocksville, N. C.

884,841. VALVE FOR FIRE-SPRINKLER SYSTEMS. James B. McGinley, Allegheny, Pa.

884,971. PNEUMATIC TOOL. Chester B. Albree, Allegheny, Pa.

884,990. METHOD OF CONSTRUCTION. James C. Meem, Brooklyn, N. Y.

1. A method of building a pneumatic caisson for excavation, which consists in driving side walls from above below the level of the water, building a fixed roof thereon, and extending the sides from the forward end as the excavation proceeds.

APRIL 21.

885,011. AUTOMATIC VACUUM CLEANING APPARATUS. William J. Bergens, Pittsburg, Pa.

885,044. TUNNELING-MACHINE. William J. Hamond, Jr., Pittsburg, Pa.

885,137. AIR-PURIFYING APPARATUS. William G. R. Braemer, Buffalo, N. Y.

885,169. PNEUMATIC BRAKE. William H. Miller, Cleveland, Ohio.

885,301. AIR-PUMP. Johann W. Sieperman, and Emil Fudickar, Elberfield, Germany.

885,319. APPARATUS FOR THE COMPRESSION OF GAS OR AIR FOR LAMPS. William H. Chipperfield, London, England.

885,361. ACETYLENE - GENERATOR. Ira Mumma, Dayton, Ohio.

885,361. AIR-PUMP FOR STREET-CARS AND ANALOGOUS PURPOSES. William A. Collins, *and* William Westerbrook, Detroit, Mich.

885,485. AIR-PUMP. George W. Kellogg, Rochester, N. Y.

885,537. PNEUMATIC-TOOL RETAINER. Edward J. Shoffner, Roanoke, Va.

APRIL 28.

885,737. PNEUMATIC VALVE. Gustave F. Dohring, Cranford, N. J.

885,783. ROTARY COMPRESOR. Cassius C. Palmer, Cranford, N. J.

885,812. PRESSURE-REGULATOR. John E. Ward, New York, N. Y.

885,844. WINDMILL-REGULATOR. Lyman S. Hagerman, Mondamin, Iowa.

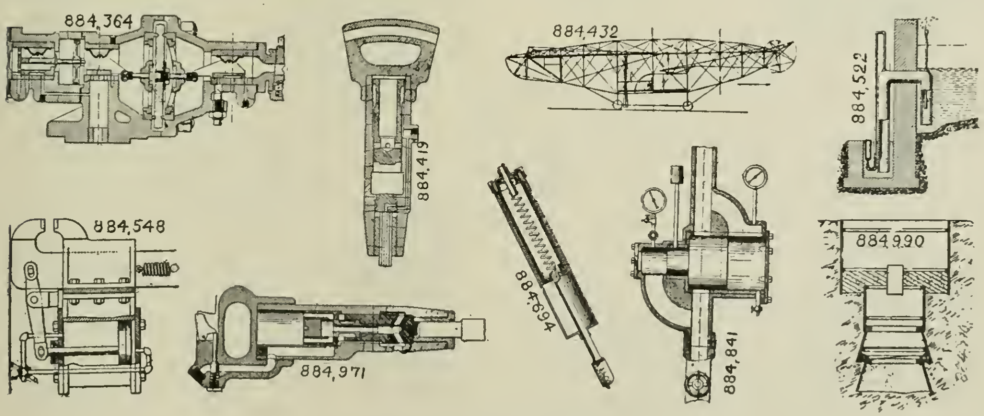
885,877. AIR-COMPRESSOR. Joseph T. Simson and Thomas Lishman, Durham, England.

885,985. PNEUMATIC TOOL. Harley M. Dunlap, Battle Creek, Mich.

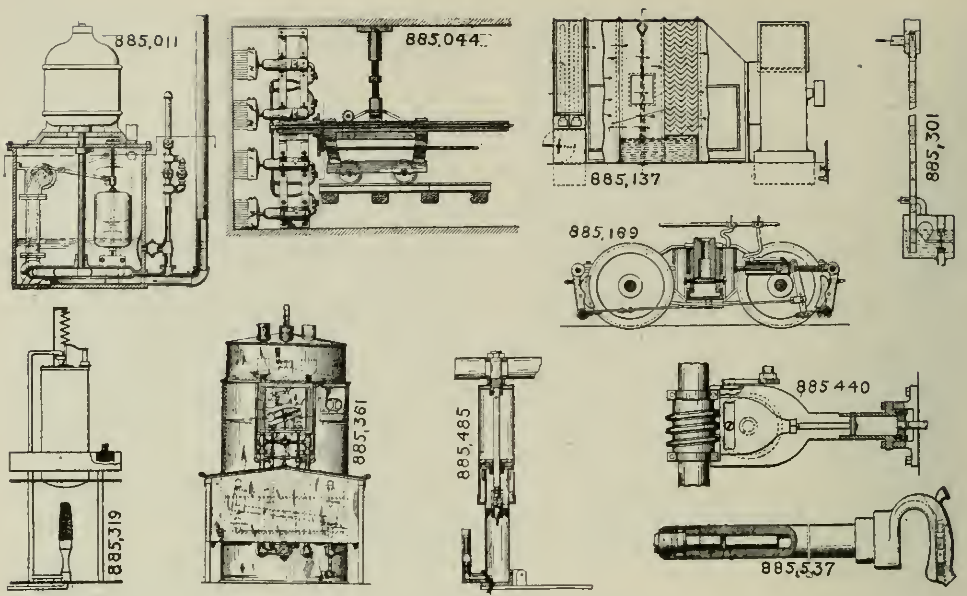
886,054. METHOD OF WORKING EXPANSION ENGINES. Fritz Hilderbrand, Deutsch Wilmersdorf, Germany.

1. The method of working an expansion engine, consisting in supplying the working cylinder with liquefied gas and compressed air, and allowing the mixture to expand, substantially as described.

2. The method of working an expansion engine, consisting in supplying atmospheric air to the working cylinder, and compressing it by means of the piston, and thereupon admitting liquefied gas into the said cylinder, and allowing the mixture to expand, substantially as described.



Pneumatic Patents, April 14.



Pneumatic Patents, April 21.

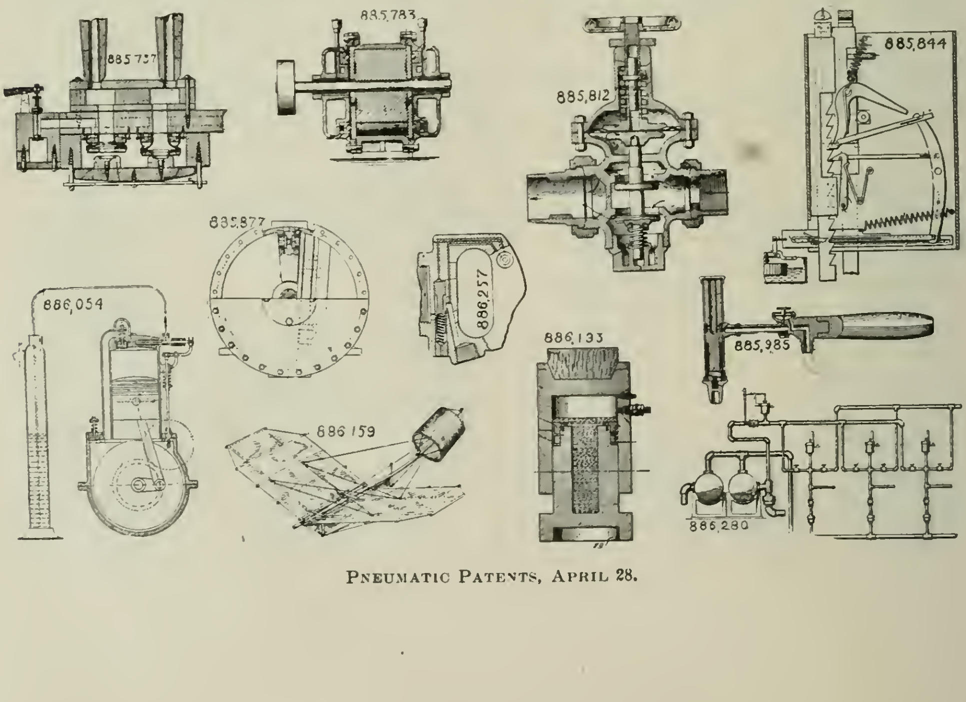
886,159. AERIAL APPARATUS. Matthew B. Sellers, Baltimore, Md.

886,193. COMPRESSED-AIR-CUSHION BLOCK. Clinton C. De Witt, St. Louis, Mo.

886,257. CONTROLLING MECHANISM FOR PNEUMATIC TOOLS. Charles H. Sergeant. Brooklyn, N. Y.

886,280. APPARATUS FOR FORCING FLUID FROM WELLS. John W. Waitz, Oil City, Pa.

1. In an apparatus for forcing oil from wells, the combination of a single pocket arranged at or near the bottom of a well, an air supply pipe and an oil discharge pipe leading into said pocket, and an air compressing device comprising a plurality of cylinders, one of which is connected with the open air and the other or back pressure cylinder is connected with the air supply pipe, whereby the air remaining in the pocket after the oil has been discharged therefrom may be utilized by being delivered into said back presure cylinder, substantially as described.



Pneumatic Patents, April 28.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC.

Vol. XIII JULY, 1908 No. 7

RECENT DEVELOPMENTS IN PNEUMATIC FOUNDATIONS FOR BUILDINGS*

By D. A. Usina, Assoc. Am. Soc. C. E.

The purpose of this paper is to review briefly the recent and very interesting development in foundations of the class generally used for the high buildings being erected in the lower section of New York City. The earth there overlies a stratum of rock, the depth of which varies from 40 to 100 ft., and the enormous loads are carried most securely by concrete piers built with pneumatic caissons, and resting directly on the substratum of rock.

Prior State of the Art.—Prior to the present improvements, the conventional type of construction was as illustrated in Figs. 1 and 2. The working chamber was built with sides and roof of heavy timber or of sheet steel with stiffeners at suitable intervals. The coffer-dam was built up in successive sections (also of timber or stiffened steel), the horizontal joints being made by angles on the inside, and the walls being braced by transverse struts, where the shape and size demanded it. The shaft was of steel tubing fastened to the roof and at the several horizontal joints by outside angles.

As the structure was sunk, to bring the upper edge of each section of the coffer-dam near the ground level, a new section of coffer-dam and a new section of shafting were added, and the space between the coffer-dam and the shafting was filled with concrete. When bed-rock was reached, the working chamber and the shaft were also filled with concrete. The finished pier consisted of two entirely separate bodies of concrete—an inverted T-shaped portion bounded by the shafting and the roof and walls of the working chamber, and a ring-shaped portion surrounding the shaft and enclosed within the coffer-dam.

The surrounding shell, consisting of the coffer-dam and the sides of the working chamber, whether of timber or of steel, could only be considered a mould for the concrete and a curb or lining for holding back the earth during the sinking of the caisson. It could not be calculated as supporting any weight, but, on the contrary, was certain to rot or corrode in time, and leave a more or less free space around the pier. The shafting, and especially the roof, where the latter was of metal and was left in place, presented very serious possibilities. Their protection from corrosion depended on the care with which the concrete was rammed into contact with them. If either corroded to a substantial extent, it would produce a very large surface of weakness. The permanence of these important elements of the structure, therefore, depended on the care of workmen, who are not to be relied on for more care than is necessary at the moment. Furthermore, the angles at the several horizontal joints formed grooves in the concrete from 3 to 6 in. deep. Only under unusually favorable conditions could the shafting angles be calculated to act as supporting a share of the load in the ratio of their horizontal area to that of the complete cross-section of the pier; but the angles at the joints of the coffer-dam would not transmit any substantial pressure to the concrete below them, because the concrete would never be rammed under them sufficiently. The only transmission of pressure would be to the decaying or corroding walls, and the angles themselves would corrode in time. The greatest area upon which the bearing strain could be calculated correctly, therefore, was that within the inner edge of the angle-irons (*X*, Fig. 2), rather than that within the inner face of the coffer-dam (*Y*, Fig. 2). As a matter of fact, the latter standard was generally used, but the error was swallowed in the large factor of safety made necessary by the uncertainties of the problem. Furthermore, the useless, and to some extent harmful, materials left in the ground, were very expensive parts of the structure.

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*Presented at the New York meeting, April 1908, of the American Society of Civil Engineers.

There were thus two powerful incentives for the elimination of these materials from the finished structure, either by sinking the pier without them, or by withdrawing them after use. Nevertheless, there was a period of many years during which little or nothing was accomplished.

The recent activity in high building construction in New York City, however, making necessary a very extensive use of caissons of this type, has witnessed the substantial elimination of every material but concrete. The sinking of the coffer-dam and of a metal or timber roof for the working chamber, has been rendered unnecessary, and the steel shafting has been designed to permit its ready removal after it has served its purpose in the sinking of the caisson. These improvements have been put into practice in the foundations of the building for the United States Express Company, at the corner of Rector Street and Trinity Place; the New Trinity Building; the building for the United States Realty Company, at Broadway and Thames Street, and the Singer Building, on Broadway near Liberty Street.

Elimination of the Roof.—The most serious objection to caissons of the style described has been the existence of the roof, constituting a dividing plane across almost the entire cross-section. The objection to such a dividing plane was appreciated from the earliest use of pneumatic caisson. The late Theophilus E. Sickles, M. Am. Soc. C. E., in 1870, and John F. O'Rourke, M. Am. Soc. C. E., in 1898, proposed the removal of the roof after the sinking of the caisson and before the introduction of the concrete above the working chamber.

The Sickles caisson is shown in Figs. 3 and 4. The roof consisted of four segmental plates bolted to the under side of internal flanges of the casing and attached to each other by bolts passing through radial flanges on the under side. After sinking to the required depth, and sealing the cutting edge with a sufficient filling of concrete to prevent the entrance of water, the air was cut off and the roof removed by withdrawing the bolts passing through the several flanges. The caisson of the type shown had a high roof and no separate air-shaft supported upon the roof, as in the modern type, the coffer-dam or outer shell being made air-tight throughout its height. For a caisson of this type, the design of the roof was probably entirely satisfactory.

The O'Rouke caisson, Figs. 5 and 6, utilized a similar roof in half-round sections, but the roof was bolted on the top of the inward flange of the casing, and the flanges connecting the segments to each other were at the top. This would permit the filling of the working chamber with concrete clear up to the roof before removing the latter.

The chief defect of these methods, however, appears in cases where, in order to get the requisite weight, the concrete is filled into the space above the roof during the sinking operation, as is usual in sinking through earth for building foundations. In such operations it has been impossible to eliminate the roof of the working chamber until the introduction of a recent improvement which, at the same stroke, eliminated the coffer-dam which had previously passed for a necessary evil in sinking caissons in earth. The feasibility of the improvement was first demonstrated by sinking all the caissons for the building for the United States Express Company by this method, and at a substantial reduction in cost.

Elimination of the Coffer-dam. There had been previously suggested, in 1904, the elimination of the coffer-dam and roof by sinking practically a solid pier of concrete, with only a central air-shaft and a working chamber hollowed out of the bottom. Fig. 7 gives a sufficient idea of the construction proposed. There was no distinction between different parts of the structure, except in so far as the lower portion of the concrete might be considered as the roof and sidewalls of the working chamber, and the concrete above this might be considered as the coffer-dam extending solidly from the surrounding earth to the shaft. It was proposed to build the whole of annular blocks of concrete laid one above another, or to form substantially a monolith by building up the structure *in situ* as fast as it was sunk. The difficulties in the way of moulding the concrete working chamber with suitably strong roof and sides and hardening it sufficiently in the short time available at the works then in hand prevented the utilization of this design,

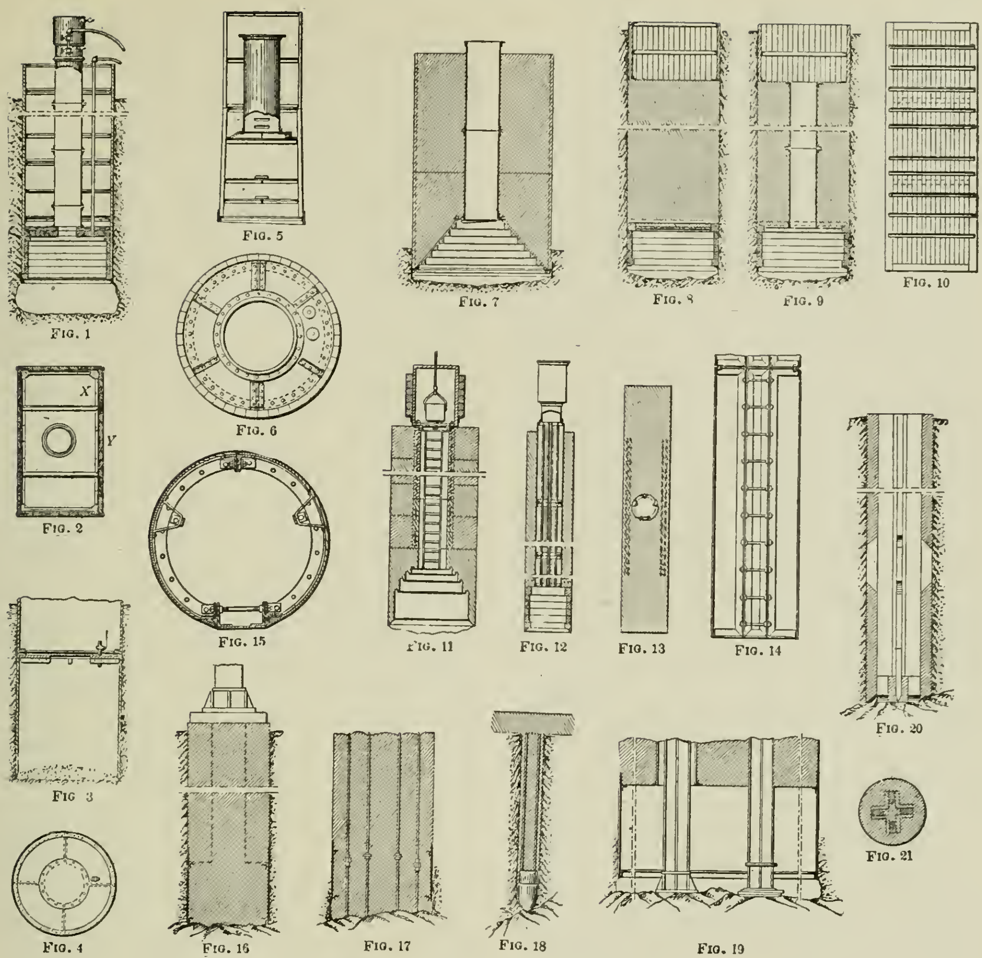

Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 6 Fig. 7 Fig. 8 Fig. 9 Fig. 10 Fig. 11 Fig. 12 Fig. 13 Fig. 14 Fig. 15 Fig. 16 Fig. 17 Fig. 18 Fig. 19 Fig. 20 Fig. 21

PNEUMATIC FOUNDATION DEVELOPMENT.

and, instead, the contractors adopted the design shown in Figs. 8, 9 and 10.

The working chamber was built of heavy timber, and across the top were laid angle-irons, a few inches below which was fastened a temporary flooring. The steel shafting was supported on this flooring, and a roof of concrete was moulded thereon to a substantial height, and of the same outside dimensions as the working chamber. The earth being excavated, and the chamber sunk to a sufficient depth, another section of concrete was added The shafting was built up from time to time to maintain it above the concrete. After the first section of concrete was finished, the successive sections were moulded in place without interruption of the sinking operations, the excavation and the building proceeding of course at the same ultimate rate, but quite independently of each other, and the coffer-dam, reduced to merely a mould for the concrete, being removed before the sinking of each concrete section.

In a previous design, it had been proposed to divide each section of the coffer-dam into flat units which might be readily transported and only united to each other when in place on the next lower section, this method having the further advantage of avoiding the necessity of breaking the air-pipes (see Fig. 1), which had been a cause of delay with the use of sections which were completed before being put in place; and such flat units were now found to be excellent moulding plates, only four being needed for each section of concrete, and excessive lengths being unobjectionable, because one might overlap the next at the corner.

The temporary flooring carried the concrete roof until the latter was hardened, and was removed before putting on the air pressure and the necessary lock. The angle cross-bars remained embedded in the concrete, transmitting its weight to the timber walls, although they were not necessary for the purpose after the concrete had hardened; and, in fact, after reaching a comparatively slight depth, the weight of the concrete was sustained by the skin friction and the air pressure, and added weights were necessary to force the caisson down. The cross-bars might have been designed and connected so as to permit their removal after the hardening of the concrete, if such removal had been thought of importance.

Only one accident occurred, and this demonstrated the advisability of using timber rather than concrete for the walls of the working chamber. The earth under one wall of the working chamber had been excavated previously to remove the footing of an old wall. When the first section of concrete had been moulded on this working chamber and the mould had been removed preparatory to sinking the concrete section, the old material replaced in the excavation allowed one side to settle so as to tilt the structure, and, before it could be righted, it fell over. The concrete was tied to the working chamber only by the crossing angles embedded in the base of the concrete, and swung bodily about the upper edge of a side wall of the working chamber, thus for a time putting its entire weight on this single wall. But the chamber was built so strongly that it was substantially uninjured, and the workmen in it at the time were unscathed. The accident, while indicating the necessity for greater precaution in building and sinking the first concrete section, demonstrated the practical excellence of the design.

When such a caisson was sunk to its final depth, there was no metal or timber roof to be removed. The cost of making first a sectional bolted roof, like that of Sickles or O'Rourke, and subsequently removing it, was saved; and, which is probably more important, the introduction of concrete above the working chamber did not have to await the sinking of the caisson. Its weight could be utilized in the sinking of the structure, and this weight, in caissons passing for a great depth through earth, is a very substantial consideration. It constituted probably the greatest of the series of advance steps under discussion.

Elimination of Shaft Lining.—The finished pier included, besides the concrete body, the cross-bars, which are a negligible consideration, being entirely embedded so as to prevent corrosion, and being of such slight cross-section as not to form cleavage planes in the concrete; and the steel shaft lining, which, at the very best, added not a pound to the load for which the pier might be safely designed, and, at the worst, might prove an element of weakness, and was certainly an element of substantial expense.

The progress of improvement in eliminating the shaft lining was the reverse of that in eliminating the roof. In the latter case, the idea was first advanced of making the roof removable after the caisson had been sunk; and the successful solution of the problem lay in avoiding the building of a true roof. In the case of the shaft lining, the first proposals endeavored to avoid its use entirely, but practical success came only with the idea of sinking the caisson with a shaft lining similar to those previously used, and removing the lining after sinking and before introducing the filling of concrete.

The first idea is shown in Fig. 11. A shaft-lining of moulded concrete is shown. To avoid excessive loss by leakage of air through the concrete, it was proposed to coat the inner surface of the shaft lining with air-tight material, such as a paint containing lime. The difficulty of connecting the shaft lining to the air-lock with sufficient strength to resist the upward air pressure on the latter was to be obviated by long tie-rods extending from the lock to the lowest section of the shaft lining, as indicated in dotted lines. It was also proposed in this design to eliminate the lining entirely, merely coring the concrete body and coating the surface with paint, as above, the manner of fastening the air-lock not being specified.

The first successful attempt to eliminate the shaft lining, however, involved the use of a removable lining, which, while casting more than those of common design, is usable again and again indefinitely, and, in the long run, effects a great economy. The design used in sinking the caissons of the new Trinity addition, and the adjoining building of the United

States Realty Company, is shown in Figs. 12, 13, 14 and 15. It was found that a comparatively small number of sections served for the sinking of many piers. There was no material loss of time involved in removing the sections and reassembling them for further use. In fact, the job was completed in much less than the previous record time for such work.

Figs. 12 and 13 show the shaft lining in place; Figs. 14 and 15 show the construction of one of the collapsible sections. Each section was composed of two approximately semicircular plates internally flanged for bolting to each other along one vertical edge, and a key interposed between the opposite edges of the plates. Internal flanges at the ends served for bolting successive sections to each other. Ladder rungs were arranged conveniently between the flanges of the key, and vertical guides were arranged just inside the line of the end flanges to guide the bucket past them. In some cases the tubing was made oblong in cross-section instead of circular. Packing was provided in all the joints, and this was the only part of the structure requiring renewal, it being cheaper to provide new packing for each re-use than to try to save the old.

Fig. 16 shows the finished pier, supposing the working chamber to be built of sheet steel. The dotted line indicates the joint between the concrete set up in sinking the pier and the filling introduced afterwards.

Comparison with Concrete Piles.—Side by side with the progress in caisson work, recent years have seen a rapid improvement in the sinking or building of concrete piles in the earth. The first attempt to substitute concrete for timber or steel in piles contemplated the manufacture of the concrete piles above ground and the sinking of them by one or another of the methods used for timber or steel piles. But, at present there are in the market several styles of concrete piles made by first forming the excavation and subsequently filling in the concrete. These methods permit the formation of piles of great depth and of theoretically unlimited diameter. Starting from widely-separated points, the two arts, caisson work and pile work, have constantly converged toward the same goal, a simple concrete column, bearing upon a rock or similar sub-foundation in the case of caissons and some piles, and supported by skin friction in the case of other piles.

The analogy has been carried even further by more recent improvements, in which vertical reinforcing rods of steel, similar to those sometimes used in concrete piles, are embedded in the concrete of the pier. The base of such a pier is shown in vertical section in Fig. 17, and Fig. 18 shows a concrete pile similarly reinforced. The reinforcing rods in the pier should extend down to the rock sub-foundation, and are most easily introduced in that method of construction in which the roof of the working chamber is omitted, turn-buckles being introduced for putting the rods under stress before embedding them in concrete. The non-adjustable flange joints may be used for the rods which run through the shaft, and substantially the entire length of which may bear freely on the sub-foundation before the concrete is filled in about them.

Most Recent Modifications.—The steel rods in the foregoing designs merely reinforce the concrete. Should the concrete fail, or be designed or built so as to shift a substantial portion of the load to the rods, the latter would be unable to stand the strain. A recent design includes the introduction of columns of sufficient strength to carry a substantial load. In fact, they may be proportioned to carry all or the greater part of the load. Fg. 19 shows the caisson sunk to rock, and the columns in place, ready to be filled with concrete. The columns are of ordinary style, built up of Z-bars riveted to a central plate. One column is embedded in the concrete from the beginning, and is wedged up at its lower end. This column may be duplicated as often as desired. Another passes down through the shaft, and is properly supported before its embedment. The shaft lining may or may not be withdrawn, as desired.

Since it is possible to carry concrete piles in many cases to a rock sub-foundation, where they act as true columns, the idea has been conceived of substituting steel, with its immensely greater strength as a column, and surrounding it with concrete, which stiffens the column to some extent, but which performs the principal function of protecting the steel from corrosion. The finished pile or column is indicated in Figs. 20 and 21. The column is hollow, which serves to carry a water-jet for sinking the column itself, and has a surrounding shell, which is afterward filled with concrete around and within the center of the column. The shell may be withdrawn as the concrete is introduced. The column may be shod at its lower end so as to secure a good bearing by ramming it down on the rock.

Invention is largely accidental, and its progress is apt to be most erratic. The writer has never observed a series of improvements progressing more logically and consistently in the same direction than those here considered. The engineering profession owes to Daniel E. Moran, M. Am. Soc. C. E., and John W. Doty, Assoc. M. Am. Soc. C. E., who conceived these improvements, and to the Foundation Company, by whom they were put into practice, a very large debt for the originality and progressive spirit with which they have met the demands of modern builders for economical methods of providing foundations of maximum bearing strength.

Spotlessly pure marbles of the island of Paros, Greece, are mined by an English company. Many of the celebrated statues left by the ancient world were sculptured from the marbles of the Parian mines. The green marbles of Tinos and the red of Mani are likewise controlled by foreign capital.

CAISSON DISEASE EXPERIENCES AND RECORDS

The following has been compiled by John E. Owens, M. D., Chief Surgeon of the Illinois Central and Chicago & Northwestern Railways, appearing originally in *The Contractor*. The first observation in caisson disease where compressed air for submarine work was applied, was made in 1820 by Dr. Hamil of Russia. In the course of the great engineering work done, diving bells were employed. Dr. Hammil took great interest in studying the effects of compressed air, not only upon the workmen, but also upon himself. In describing his own experience, he states that at the depth of five or six feet severe pain was felt in the ears, which was relieved in a measure by swallowing. At fifteen or sixteen feet there was a noise in the ears like an explosion, followed by entire relief from pain. His respiration was perfectly easy. The ascent was accomplished with much less inconvenience than the descent. He states that one of the workmen became so accustomed to the air of the bell, as to be uncomfortable under the usual atmospheric pressure.

In 1822 M. Triger devised an air-chamber or a shaft that was sunk near the river Loire, France, for the purpose of reaching coal underlying a quicksand sixty-five feet, thick, and full of water percolating from the adjoining river.

The apparatus consisted of a steam engine, two air pumps and an air vessel. The air vessel had a stuffing-box fixed to its lower part, intended to connect it with a wrought-iron pipe, in such a way as to cut off all communication with the outer air. A supply pipe for the conveyance of compressed air from the pumps to the shaft, and an outlet pipe for the discharge of water, was added. Two man-hole valves, designed for passing men and material into and out of the air vessel, two air locks, a pressure gauge and a safety valve, completed the apparatus.

J. Hughes, assistant engineer at the Rochester bridge, England, noted that the men at work in the compressed air had a remarkable increase of appetite for food. Respiration, he said, was "slightly affected," and when the transit of the air-lock was rapidly made, there was some complaint of, headache. The greatest depth under water was sixty-one feet.

Boinet says that effusions of blood are habitually observed in caisson disease. He also assigns as a cause the formation of gas emboli in the vessels, due to a too sudden decompression. He quotes Lorraine Smith, who speaks of toxemia which is produced by the oxygen accumulated in the air under high pressure; but Boinet believes that the pressure in the caisson is not high enough for the oxygen to become toxic. Paul Bert attributes the condition to bubbles of gas in the capillaries and the internal organs.

Boinet further says that we must take in consideration the predisposing conditions of men employed in the kind of work under consideration of such as age (over 45), pulmonary affections, fatigue, alcoholism, a meal, especially when large, before the emersion. We must also take under consideration the depth of immersion and the rapidity of the decompression.

The divers should know of the two most

important premonitory signals, viz., special pains, and temporary paralysis.

Of the sixty-four men employed in a caisson on the banks of the Loire in 1884, sixteen had severe attacks, and it was necessary to discharge twenty-five on account of sickness. Two cases resulted fatally. Very often, when life is not lost, the ensuing paralysis is permanent.

Albert Smith records the effect of high atmospheric pressure on the body as follows:

1. The pitch of the voice is changed from a bass to a treble and protracted conversation becomes very fatiguing.

2. The effect on the cutaneous vessels is shown by the pallor of the face, which is very marked, and continues for fifteen or twenty minutes after leaving the caisson.

3. During the work in the Brooklyn bridge caisson, when the pressure was about thirty-two pounds, he took the temperature of seven of the men an hour and a half after entering the caisson, and found that it averaged 99 degrees F. At first he accepted this as a result of the increased interstitial change so strongly insisted upon by Dr. Jaminet of St. Louis, but subsequent observations led him to interpret it differently.

The temperature of the body in health is kept at about normal by constant evaporation from its surface, but in the caisson, as already mentioned, the air was already nearly or quite saturated with moisture, so that evaporation from the surface must have been practically suspended. With the temperature of the air at 76 degrees F., as it was at the time of the observations, and the men engaged in severe labor, it is easy to see how the absence of the cooling process of evaporation from the surface would lead to a rise of one degree of temperature.

4. Circulation: Upon entering the caisson, the pulse immediately rises to 120, but gradually falls back to its normal standard, and sometimes below it.

The effect of high atmospheric pressure upon the volume of the pulse is always, according to his observation, to diminish it. This is easily accounted for by the pressure exerted upon the artery, which prevents its yielding readily to the expanding of each successive wave of blood. Hence the pulse is small, hard and wiry.

5. Upon the Perspiratory Function: Several writers have observed that it is immediately remarked by every one entering a caisson that the secretion of the skin is apparently immensely increased, noticeable even when the temperature of the air is moderate, but as this increases it becomes a very serious annoyance. The clothing quickly becomes saturated, which, besides the discomfort it occasions, exposes the wearer to great danger of taking cold on going into the open air. But a little examination served to show that in the Brooklyn bridge caisson at least there was really no increase of the secretion from the skin, but instead of evaporation, there was an accumulation of moisture, simulating excessive sweating upon the surface.

6. Upon Digestion: Nearly all authors who have written upon the effects of compressed air, agree that, for a time at least, it increases the appetite to a remarkable extent. Indeed, this is one of the first and most favorable results observed where compressed air is applied remedially. It was frequently remarked by the men working in the New New York caisson of the Brooklyn bridge, that their work made them unusually hungry, and that they could not get enough to eat. Of course it was not possible to obtain any exact data as to the relative amount of food consumed, but from careful inquiries it was considerably in excess of what is usual in the case of men engaged in similar labor in open air.

Jaminet, in his observations at St. Louis, found that the amount of fluid secreted by the kidneys was very much increased, in some instances nearly doubled, while the specific gravity was little if at all below the usual average. This shows that the solid matter excreted was also in much greater quantity than usual.

Corning has studied a number of cases of caisson diseases in the workmen employed on the Hudson River tunnel. The most common symptom, and usually the initial one, was pain, followed by loss of power and anesthesia. These may continue and other symptoms develop, presenting the picture of acute myelitis, and cerebral symptoms may sometimes follow. The first ones are relieved if the patient at once returns to the caisson. The symptoms are considered to be due to the abrupt transition from an atmosphere of a high density to one relatively rarefied, as has been felt in aeronauts who ascended to great heights, who were immediately relieved when they descended to lower levels.

In 1861, Robert P. Brereton, an assistant engineer, engaged in the construction of the center pier of the Royal Albert bridge at Saltash, England, reported that during the time required for the installment of this pier, air-pressure reached forty pounds above the normal; usually the pressure was much less, as the water in the main cylinder was kept down by pumps. He observed that at first his men worked too long at a time and on coming out they were slightly paralyzed, but in two or three days they recovered. With three-hour shifts the men could continue to work for several months consecutively.

John Hawkshaw, the celebrated bridge builder, at the construction of the Londonderry bridge, where seventy-five feet pressure was experienced, noted some casualties, and that one of the effects produced by the air-pressure was that the joints of some of the less robust men began to swell.

Oliver, of Newcastle, (Eng.), describes an enormous caisson in which thirty-five men could work at the same time. The chamber was forty-five meters long. He says that the early symptoms during compression are, as a rule, an unpleasant sensation in the ears or a deafness. Other symptoms may appear immediately after leaving or several minutes or hours after.

The causes of caisson diseases are attributed, in general, to too long a stay in the caisson, too high pressure, or too rapid decompression. The less important symptoms are muscular pains, sometimes necessitating morphine hypodermically, bleeding from the nose or mouth, abdominal pains and vomiting. The grave symptoms are paraplegia, convulsions, and sometimes, though seldom, sudden death. Such elements as increase of the pressure, the degree of impurity of the air in the chamber or of that forced into it, duration of rest between hours of labor, the condition of health of employe, the rapidity of the decompression, contribute to the development of caisson disease. Oliver lays great importance on the factors of impure air, and rapidity of the decompression.

At the foundation of the Rochester bridge (Eng.) across the Medway, Dr. Hally experimented for the effects upon four other persons. They remained under water, at a depth of ten fathoms, for an hour and a half, in a diving bell improved by his own ingenuity; nor was it considered any limit existed as to the period they might have continued down with equal safety. A sharp pain in the ears, of short duration, was the only inconvenience acknowledged.

Dr. A. Jaminet has left a most interesting account of his experience. He was employed by Mr. Eads, engineer of the construction of the Mississippi river bridge of St. Louis, to take charge of all the men at work in the air-chamber, and to establish such regulations as in his judgment the well-being of the men demanded. A floating hospital was established in a boat lying just below the pier. Besides ordinary accommodations, berths were fitted up in which workmen could lie down during their hours of rest.

Dr. Jaminet had been a frequent visitor to the air-chamber, and had himself felt the peculiar effects of compressed air. He had been much interested in testing the familiar law regulating the boiling point of liquids, when under pressure, and in noting the effect of the compressed air upon himself and those who entered the caisson with him.

He had noted the men as they came from the air-chamber. Their appearance was pallid and they were cold. In some the pulse was quick, varying from 95 to 110, but somewhat weak; with others it was as low as 60. Without exception the workmen complained of fatigue.

The pulse always quickened on entering the air-chamber, though it soon fell to the normal, and even lower, in the course of a watch. On one occasion the pressure was 32½ pounds more than that of the atmosphere. He recorded the pulse himself and five other visitors as follows: Before entering, 81, 78, 78, 79, 79, 80. Temperature 56 degrees of external air. They were ten minutes in the air-lock. At the end of six minutes their pulses were 100, 88, 98, 86, 95, 90 thermometer 62 degrees; temperature in air-chamber 48 degrees. In twenty minutes all felt a marked exhilaration. At the end of two hours their pulses were 68, 70, 71, 69, 70, 72. Their chests expanded during inspiration normally. They spent 5½ minutes in the air-lock on their return, but they felt very cold. Thermometer fell to 37 degrees in four minutes. Before ascending stairs, pulses stood 69, 70, 69, 71, 68, 72; after climbing the stairs, 106, 104, 92, 94, 102, 99.

The air-lock was, as a rule, excessively warm when the pressure was increasing, and exceedingly cold when the pressure was diminishing.

Dr. Jaminet always complained of cold in the air-lock, returning, and severe epigastric pain about ten minutes after coming out.

On the day the caisson touched the rock (pressure forty-five pounds) he remained in the chamber two and three-quarters hours. While in the air chamber he felt well. In the air-lock, on his way out, he was conscious of a great loss of heat, and he suffered a violent pain in his head. The air was escaping very rapidly. The chief engineer was with him in the lock, and, as was usual with him the discharge-cock was wide open. At Dr. Jaminet's request the escape of air was stopped a moment; the time spent in the lock was, however, but three and one-half minutes.

With difficulty Dr. Jaminet climbed the stairs. His pulse was 110; he was suffering severe epigastric pain, and his strength was nearly gone. He went directly ashore on the first boat. With great exertion he managed to walk from the boat to his carriage, which was about 100 yards away, and climbed in. He was able to drive to his house, half a mile distant and stagger into his office, where in a few minutes he became paralyzed. For some time he could not speak, but he retained consciousness. Gradually he gained command of himself, but his suffering was intense, and for three or four hours he considered his life in extreme danger. It was over twelve hours before he began to move his legs. A little later he was able to walk, but he was feeble for some days.

He made several careful investigations upon the amount and character of the waste of the human system while in the air-chamber. He found that, invariably, an abnormally large amount of urine was secreted, and that it contained unusually large amounts of urea. He estimated the amount of urine secreted during the twelve hours from 7 a. m. to 7 p. m., on the average 28 or 30 ounces per man, and the quantity or urea was far in excess of that found in the urine of a healthy laboring man when working in normal atmosphere. The men drank water freely. They had liberty to spend their off-hours as they pleased, but the doctor requested them to lie down in the berths, provided for that purpose, for at least one hour, immediately on coming up. However, the men refused to obey the order of the physician as to the hours of rest. Each man was subjected to a rigid physical examination. All old hands deemed unsuited to the work were discharged and unpromising applicants were rejected.

A man whom the doctor had once rejected came with a friend, and entered the air-chamber without the doctor's knowledge. At the end of the second watch he was seized with severe cramps and paralysis and it was months before he fully recovered.

There were several other cases at the East pier, and one of them was very serious. The man was badly paralyzed and broken down. After lingering about a year he died. In the West pier a very bad case occurred under an air-pressure of forty pounds (ten pounds less than in the East pier). The patient was sent, with several others, to the floating hospital, but the case, however, resulted in death. The man was really unfit to work. He had been a hard drinker for the past year, though he declared he was sober the day he went into the air-chamber. He worked but two hours.

A boy had been smuggled in by a friend and was taken sick the first day. The next day the doctor sent him home, with the injunction not to return; but he came back two days after and entered the caisson. After the first watch he was attacked again, and did not recover for a month. On each occasion he was insensible when carried to the hospital. He was 20 years old and very slightly built.

In a period of fifty days there were fourteen cases of cramps and paralysis. Later, notwithstanding the physician's vigilance and care, cases of cramps and paralysis were of almost daily occurrence.

At the East pier men worked three watches of one hour each, distributed over twelve hours; pressure forty-nine pounds. On the first day there was one case, which resulted in speedy death. The victim had worked three months at the other pier, and had suffered no inconvenience. He was on duty from 8 till 9 o'clock, and felt well after coming up. As he had neglected to bring his dinner he was allowed to go ashore at 11:30 to get a meal. He, however, got nothing to eat, but drank in a saloon. He returned just before 1 o'clock, and worked from 1 till 2. On leaving the air-chamber he, in common with the rest of his gang, came through the air-lock in less than four minutes. He was taken sick in the air-lock and was unable to climb the stairs. He became unconscious while being brought up, and died two hours afterward.

It appears that the temperature in the air-chamber was unusually high. The external air was 66 degrees, and as no adequate cooling apparatus was in use the air from the pumps must have entered the caisson very much heated. On the following day the air-supply came through a coil of 150 feet of copper pipe immersed in the river. The temperature in the air-chamber then fell to between 60 and 70 degrees.

The doctor at once transferred the ice box to the air-lock, and enforced his rules strictly. in spite of the efforts to keep down the temperature, the men complained of the heat, and of being very tired on coming out, and, not infrequently, of having headache. As soon as a man complained of pain or numbness he was required to rest over one watch.

To prevent men reckless of danger from passing through the air-lock too rapidly, the size of the inlet and discharge pipes was changed, so that though the valve was wide open, the stipulated time could not be curtailed. One can imagine the imprecations bestowed on the slow coach by the men in haste to get out.

At least three-fourths of the cases that died, worked in the air chamber only one day, and mostly but a single watch of two hours. Of all those that died from the effects of compressed air, eight post-mortems showed the brain and the spinal cord were congested in all, and in most of them the interior organs of the bodies were also congested. There was no doubt as to the immediate cause of death.

An air compressor is an item which should never be overlooked in an electric substation of any considerable size, as the life of any electric apparatus depends to a very large extent upon its cleanliness. Having a small automatically controlled compressor and a receiver in which a suitable pressure is maintained, the air should be piped to various points where cocks should be provided and ready means for attaching rubber hose.

STEAM OR AIR FOR POWER HAMMERS

The accompanying table we reproduce from *The Engineer*, London, with the comments of *The Engineer* thereupon. All reliable contributions to our mass of engineering data are to be welcomed, and all may be of use in their place. It is rarely, however, that matter such as here presented is ever decisive of the question proposed, since no prepared conditions can reproduce these of actual and unpremeditated practice. The relative costs of steam and of compressed air consumed for doing certain work with the hammer really give little hint of the final costs of operation, since the condition perhaps most affecting the result is that a hammer is never operated continuously, and it is the constant expense of standing always ready and the delay and inconvenience of warming up every time the hammer is used which alone should often lead to the choice of air as the operating medium, entirely regardless of the actual cost alone of the air or the steam used. *The Engineer* says:

Although everybody is prepared to admit that compressed air possesses certain advantages over steam for operating power hammers, the sweeping statement sometimes met with that the former is the more economical in steam hammers is not confirmed by impartial investigation. Messrs. B. and S. Massey, the well-known firm of pneumatic and steampower hammer makers, have recently published tables which throw considerable light on the subject. The properties of steam and compressed air are so nearly alike that it is safe to say that the same amount of work can be done in a hammer cylinder by a given volume of each, measured at the same pressure. Thus, in the third lines of the two tables there are given quantities of steam and air respectively, each of which has a volume of 10,000 cubic feet at 60 lb. pressure per square inch. These two quantities will therefore be capable of doing the same amount of work in the cylinder. In column five are given the costs of obtaining, under certain possible conditions, the various quantities of steam or compressed air. Non-expansive working has been assumed, the work being in each case 86,400,000 foot-pounds, but the equality is substantially maintained, even if a considerable degree of expansion be used. Very slight expansive working is, however, possible in steam-

Table of Costs of Steam.

	1 Gauge pressure, per sq. in.	2 Weight of steam.	3 Volume measured at pressure given in column 1.	Data assumed.	5 Cost of coal, labour, and boiler maintenance. Labour and boiler maintenance are included at the estimated rate of 2s. per ton of coal used.		
					Price of coal 10s. per ton.	Price of coal 17s. 6d. per ton.	Price of coal 25s. per ton.
	lb.	lb.	cu. ft.		d.	d.	d.
(I.)	30	2198	20,000	5 lb. of steam delivered to hammer per lb. of coal burnt. (Thus allowing in the case of a boiler supplying 7½ lb. of steam per lb. of coal, for the condensation in the pipes of ⅓ of the steam supplied by the boiler.	28·3	45·9	63·5
(II.)	45	1990	13,333		25·7	41·2	57·6
(III.)	60	1753	10,000		22·6	36·6	50·8
(IV.)	80	1666	7,500		21·4	34·8	48·2
(V.)	100	1579	6,000		20·4	33	45·6
(VI.)	125	1500	4,800		19·4	31·4	43·4
(VII.)	150	1480	4,000		19·1	30·9	42·8

Table of Costs of Compressed Air.

	Gauge pressure, per sq. in.	Volume of free air at 60 deg. Fah.	Volume measured at pressure given in column 1. and at 60 deg. Fah.	Data assumed. Air taken in at 60 deg. Fah., and cooling again to 60 deg. Fah. after compression, and used at 60 deg. Fah.	Cost of power for compressing the air. 1.—Electrically-driven compressor. Average efficiency of motor 85 Price of current per B. of T.U. (K.W. hours) 1d. | ¾d. | ½d. 2.—Belt or gas-driven compressor. Price of power per B.H.P. per hour.		
					·88d.	·66d.	·44d.
	lb.	cu. ft.	cu. ft.		d.	d.	d.
(Ia.)	30	60,800	20,000	Single-stage compressor without water cooling 9·85 B.H.P. per 100 cu. ft. free air per min.	87	66	44
(IIa.)	45	54,132	13,333	Ditto, 12·6 B.H.P. per 100 cu. ft. free air per min.	99	75	50
(IIIa.)	60	50,800	10,000	Single stage compressor with water cooling 14·3 B.H.P. per 100 cu. ft. per min.	106	79	53
(IVa.)	80	48,300	7,500	Two stage compressor with water cooling and inter cooling 15·5 B.H.P. per 100 cu. ft. per min.	108	82	54
(Va.)	100	46,800	6,000	Ditto, 16·63 B.H.P. per 100 cu. ft. per min.	114	86	57
(VIa.)	125	45,600	4,800	Ditto, 18·6 B.H.P. per 100 cu. ft. per min.	124	93	62
(VIIa.)	150	44,800	4,000	Ditto, 20·2 B.H.P. per 100 cu. ft. per min.	132	99	66

COSTS OF STEAM AND OF AIR FOR DRIVING POWER HAMMERS.

hammer cylinders. With air the further difficulty presents itself that to obtain any appreciable degree of expansive working involves a large drop in temperature, to guard against which it is necessary to reheat the air—a costly proceeding with such machines.

From the data supplied in Messrs. Massey's tables it is seen that as regards the items of cost here given it is generally more economical to use steam than compressed air. For instance, if the figures for 60 lb. steam pressure be compared with those for 45 lb. air pressure—the latter being regarded by the authors as the most economical air pressure to work at—with reference to a works where coal is obtainable for 10s. per ton, and electric current cost 1d. per unit, or belt power 0.88d. per brake horse-power per hour, the cost will be as 22.6 is to 99; or, stated otherwise, the cost of steam driving will be less than one quarter of that of air operating. On the other hand, in a works which has to pay 17s. 6d. per ton for fuel and only ¼d. per unit for electric energy, or 0.22d. per brake horse-power per hour for belt driving, air comes out the cheaper. Broadly, however, it may be calculated that the cost of driving by steam and air will be about the same in a works where coal costs 25s. per ton and electric power ½d. per unit, or belt power 0.44d. per brake horse-power per hour.

An interesting feature observable in the tables is that the cost of steam decreases as the pressure increases, while with compressed air the reverse is the case.

PNEUMATIC TUBES FOR THE FACTORY

By Richard H. Libbey.

A problem which at the present is receiving more attention than in the old days is that of transporting tools from the tool room to the machinist. In a great many shops the machinist has to go to the tool room when any tool is wanted, and in other shops a helper is sent on the errand. A step higher than this is the shop where by pressing a button the machinist calls a boy who can do the errand. Another problem, which comes up when the idea of centralization of the various departments in different buildings is carried out, is that of transporting small articles from shop to shop, or between office and shops. A telephone order is likely to be misunderstood, and, in at least one large and modern factory, the motto, "Verbal orders don't go," is strictly adhered to. To carry the messages, drawings, orders, etc., back and forth boys are often employed, but boys are rather slow, and liable not to be on hand promptly when wanted. The solution of these problems is easily found in a pneumatic tube system. A tube is run to the various points which are to be in communication, and the article to be transported is placed in a carrier, which is forced through the tubes by air. Tubes from 2½ to 8 inches inside diameter are used for manufacturing plants, the smaller tubes for messages, drawings and the like as well as small tools, and the larger tubes for communication between various buildings.

There are two pneumatic tube systems in use, one being the pressure system, in which compressed air is forced into the tube behind the carrier, and the other is the vacuum system, where an exhauster is used which, as we say, sucks the carrier through the tube. The pressure system is preferable for shop purposes.

In the vacuum system two tubes, an outgoing and an incoming, are required. Besides these there is also an exhauster pipe which is tapped into the suction tubes and which runs to the exhauster. The pressure difference in the tubes is from 6 to 12 ounces per square inch, which will easily take a carrier weighing half a pound; but there is no reserve power to help to start the carriers if they get stuck in the tube. The horse power required depends upon the number of bends and the amount of service required. For half-pound carriers at pressures of 6 to 12 ounces per square inch an allowance of one-fourth to one-half horse power for each line is sufficient. The carriers travel at a speed of 1,000 to 2,500 feet per minute. This system assists in the ventilation; but 12 inches away from the end of the suction pipe no draft can be felt.

At the central station the terminal of the tubes is rather simple, the outgoing tube having a bell-shaped mouth and the incoming tube end being covered by a clapper which is forced open by the carrier. At the single or local station an air-tight metal hood or its equivalent is used, and the outgoing or suction tube is tapped into it as well as the incoming tube. This system is illustrated by Figure 1. The clappers swing outwards so that the carriers can pass through easily, and the clapper closes the opening almost instantaneously the suction through the tube is not broken enough to prevent the passage of another carrier going in the same direction in the tube. This arrangement of the single stations lessens the amount of exhauster piping, as all the tubes can be tapped near the central station and the exhauster can be placed close at hand.

The pressure system requires an air pump or compressor, which compresses the air to the required pressure, and an air receiver which is simply an air-tight tank. This acts as a reservoir, assisting in maintaining an even air pressure, and minimizing the pulsation due to the strokes of the pump. It also assists in taking the moisture out of the air. As an air compressor and receiver is a part of the equipment of most of the plants that would be likely to put in a tube system, a reducing valve and a separate low pressure air receiver may be easily installed. Then the plant can be utilized at a slight additional cost. If the compressor capacity must be increased it is often better to put in another high pressure compressor and use a reducing valve to lower the pressure to that required for the tubes. Then the high pressure air would be reduced in pressure and discharged into a low pressure receiver, being piped from there to the tube terminal valves by ordinary wrought iron pipe. With two high pressure compressors the plant would not be left without compressed air in the case of anything going wrong with one of the compressors. When a compressor is used it is well to put

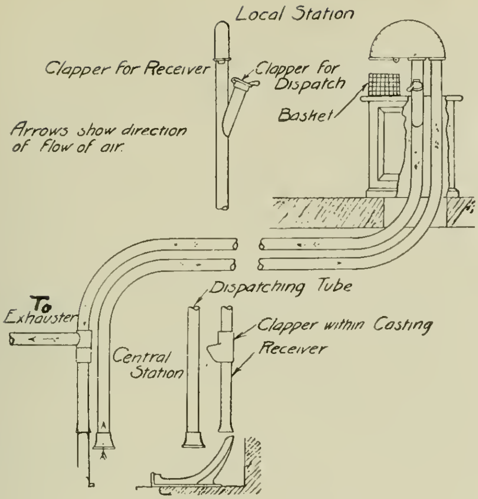

FIG. I. VACUUM SYSTEM.

in an automatic regulator also. By means of this regulator when a certain predetermined high pressure is reached the air will be by-passed around the piston so that the compressor will not be pumping against any pressure; or, by another scheme of regulation, the compressor will be stopped. When the pressure drops a predetermined amount the automatic regulator will start the compressor by closing the by-pass; or in the latter case by starting the motor or engine.

With the pressure system, which is illustrated by Fig. 2, the tubes are normally open to the atmosphere, but the terminal valves are so arranged that when a carrier is to be dispatched and the cover is closed it operates an auxiliary valve, which admits air under pressure behind the carrier. As the air supply pipe is smaller than the tube the air expands to a lower pressure if the carrier runs easily. If for any reason the carrier stops the air pressure rises until normal pressure is reached. If the carrier then fails to start the full pressure of the compressor can be turned into the line. This cannot be done with the vacuum system. When the carrier reaches the terminal for which it was dispatched it rushes out and, while doing so, actuates an auxiliary valve, which admits air into a small iron pipe noted as the releasing air pipe in Fig. 2. This pipe leads to a valve at the other end of the tube and admits air under a diaphram which is forced upwards, and in so doing unlatches the cover which by the aid of a spring or of gravity swings open. When it opens the air pressure on the main tube is shut off, thus preventing any waste of air and making an economical system, as power is being used during the passage of the carrier only. In the vacuum system there is a constant current of air. The auxiliary valve operating the unlatching or releasing mechanism is controlled by a dash-pot so that it shuts off the air just as soon as the diaphram has done its work. Instead of the auxiliary valve, pipe and diaphram arrangement a contact lever and an electro-magnet has been arranged in some cases and has been found to work satisfactorily.

While the pressure system requires only one carrier tube between two points of communication it does require that an ordinary iron pipe be run to the valves to carry the air to them. Two carriers at opposite terminals cannot be put in the tube at the same time as the outward rush of air at the terminal towards which the carrier is travelling would prevent the second carrier being dispatched. Usually the time of transmission is so short that no inconvenience is caused by the single tube.

The tubes for the vacuum system and also for the pressure system up to four inches inside diameter are of brass, hard brass tube being used for the straight runs and annealed

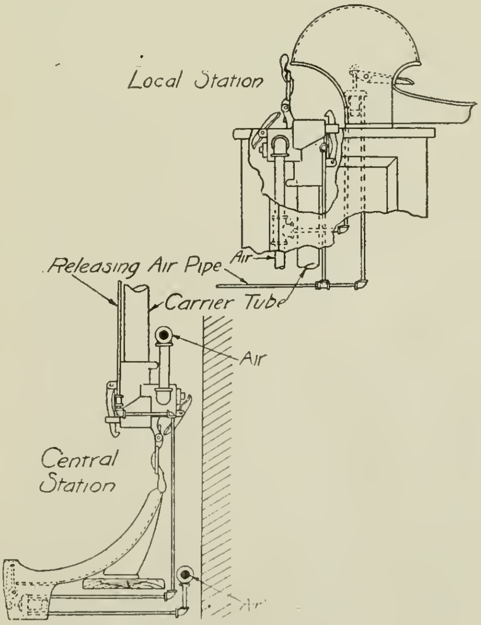

FIG. II. PRESSURE SYSTEM.

brass tubing for the bends. The tubes must be bent at a large enough radius so that the carrier can pass through easily without jamming, and all the joints must be flush and smooth so that there will be no sharp corners or burrs for the carrier to catch or rub against. When bending the practice of some manufacturers is to fill the tubes with melted rosin and allow it to solidify. After it has become thoroughly cooled and hardened the tube is bent over a form until the proper radius is reached. For tubes 2¼ and 2½ inches in diameter a minimum radius is three feet, and some use a larger radius, but three feet is sufficient for carriers of the ordinary length. After bending, the rosin is melted out of the tube and it is cleaned and polished. To test it it can be set up and a carrier dropped into it. If it goes through easily by gravity it can be depended upon as being all right. There are machines now in the market that can bend the tubes without being filled.

The straight runs are composed of a series of shorter lengths of tubing which are joined by a butt joint and over which a close fitting jacket or sleeve, also made of tubing, is clamped. This gives an air-tight joint, and one that cannot get out of line, as the jacket extends several inches each side of the joint. When the tubes are put up care must be taken to make a perfectly smooth joint and then there will be no trouble.

The eight-inch tubes are made of cast-iron pipe bored to the correct diameter. These are of the same form as the ordinary water and gas pipes, and the joints are made with yarn and lead in the usual manner. The bends are made of brass tubing. Two tubes, an outgoing and an incoming, are used, although the system is operated by compressed air. The terminals are more complicated than for the smaller tubes. The tube has a transmitter at one end into which the carrier is placed, and it is then tipped up, allowing the carrier to plunge through the clapper or gates and on into the tube. As there is a constant current of air the carrier is caught in the current and forced along at the rate of about 30 miles an hour at an air pressure of 9 pounds. At the receiving end there is an air lock arrangement that keeps the heavy carrier from banging into the terminal gates and receiver. With the smaller tubes the terminals are usually set vertical, discharging and receiving either upwards or downwards. With the larger tubes the receiving station is set horizontally. For obvious reasons the eight inch tubes cannot be bent at as small a radius as the little tubes, and this has to be taken into account when making a layout.

Carriers for messages are made of leather, open at one end with a felt washer or buffer at the other. For other uses the carriers are made of brass tubing with felt ends and a sliding cover in the side which allows the contents to be securely held in the carriers. The carriers for the larger size tubes are made of sheet steel with bearing rings near each end and a felt buffer at one end, while the cover is at the other end.

To even up all that has been said, it can be mentioned that the pressure system is the best for shop use, where tools and other articles are to be transported, because it has a reserve pressure which can be turned into the line to force any heavily loaded carrier along. With this system only a brass tube and a small iron pipe are required between two stations. If an air system is in use the only addition to the plant that is necessary is a reducing valve, and, finally with this system power is being used only when a carrier is in the course of transportation. With the vacuum system there is no reserve power to help out. Two brass tubes are required to complete communication between two stations. An exhauster must be installed and the system is using power continually. With both systems the air pressure is low and the valves are simple in operation and design, and there is no delicate mechanism to get out of order. The wear on the tube is so small as to be immaterial, and if by an accident a hole should be punched in the tube there will be no serious damage done. The outrush of air under low pressure will do no one any harm. Either system, when once installed, offers an economical, speedy and sure way in which the problem of transporting tools and small articles, as well as orders, messages and drawings to various points can be solved.—*Industrial Magazine.*

One astonishing discovery by the use of anchored balloons with self-registering devices at Strasburg, Germany, is an isothermal zone in the air at a height of about 40,000 feet, in which, contrary to experience in the lower regions, temperature does not diminish with recession from the earth.

COOLING AIR FOR COLD STORAGE

The following we abstract from *Ice and Cold Storage,* London. There is one main principle on which air is cooled for use in cold rooms of large capacity, but the methods of applying the principle are various. The principle alluded to is that of propelling air through a chamber containing some cooling agents.

The application of this principle in its simplicity is illustrated in Fig. 1, in which A is the duct by which air enters the cooling chamber CC. To force air into such a chamber and then to circulate it through a dozen rooms or more calls for some means of driving it along, such as a fan or air propeller fixed at a point, as F, just before the entrance to the cooling chamber.

The cooling chamber is arranged according to the following methods in the United Kingdom. In some cases two or more tiers of pipes, P P P, running lengthwise, are fixed in the chamber, a refrigerant being passed through them when the plant is at work. The refrigerant most commonly used is brine cooled to between 10 and 26 degrees Fahr. This wide range of temperature is of interest as presenting a phase of the working about which questions of economy arise. In some cases the cooling agent is a refrigerant in a vaporous condition. The cooling then is effected by "direct expansion," the refrigerant entering the pipes under conditions as regards pressure and temperature, which cause it to change from liquid to vapor, extracting heat from the pipes which confine the thus vaporized refrigerant, and from whatever may be in contact with them, which would be the air occupying the chamber. Whether brine, ammonia or carbonic acid were used the cooling principle would be the same; the air being in contact with the pipes containing the frigrant would be deprived of heat by them, and its temperature would be lowered.

Usually cold brine is also made to flow down over the outsides of the pipes, their entire surfaces being laced by the liquid. The brine prevents the accumulation otherwise of a deposit of non-conducting frost on the pipes, and also has a direct cooling effect of its own.

Another plan is the plate cooling method, in which pipes containing a refrigerant may or may not be used. The essential cooling media are plates of thin galvanized metal, corrugated or flat, fixed either upright or on edge, with a flow of cold brine maintained downwards all over them, the aim being to maintain a thin film of brine on all the plate surfaces. In some cases the plates are three inches apart and sometimes more than this. The plates being usually lengthwise of the chambers, tthe air in passing through comes in contact with them, and is effectually cooled.

By a third method of cooling a number of discs of thin galvanized metal, two or three feet in diameter and either flat or slightly concaved, are mounted on spindles which rest across a tank on the floor of the cooling chamber to hold the cold brine, about one-third of the disc area being submerged. A slow rotation of the spindles keeps the discs constantly wet.

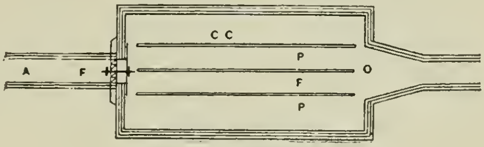

FIG. 1

The spray method has as its chief feature the maintaining of a continuous shower of brine over the area of the cooling chamber. The fall of the shower may be direct or interrupted by a succession of perforated cross trays. The air driven through the cooler comes in contact with the particles of cold brine. A proper combination of pipes and plates makes a very effective cooler.

In the practical working of either of these coolers conditions may be noted which suggest modifications. The spray plan, for example, has at times produced very unfavorable results. The particles of brine have been carried away by the strong current of air and deposited on meat or poultry in the storage rooms.

In the construction of an air cooler, the surface area of the pipes, plates or discs provided for cooling the air blown through the cooler will, it may be assumed, be determined by the aggregate volume of the air contained in all of the rooms, and in the air-circulating trunks when the store is working at its maximum. In theory a known volume of air (*a*) may be cooled sufficiently to admit of a cold store working satisfactorily at its maximum, by the said volume being kept in constant circulation through a cooler having a minimum cooling capacity (*b*). In strict theory, the determination of the ratio between the cooling capacity of the cooler and the cooling duty to be performed could be easily determined; but in the usual working of a cold storage plant variations are inevitable.

As already stated, the cooling agent may pass through the pipes at 10 degrees F. or at 26 degrees F., or at any degree between, and the brine showered over the pipes may show a like variation in temperature. Here, obviously, are factors which may interfere greatly with the theoretical ratio between (*b*) and (*a*), one is forced to provide for a compromise as between the theoretical ratio named and the ratio between the work actually to be done (*c*) and the efficiency of the cooler (*d*). This brings the enquirer to the practical conclusion that the most *effective* device for cooling air while passing *through* the cooler will prove at once the most economical.

Referring to Fig. 1, it will be obvious that if the space between any two tiers of pipes (P P) in a cooler be, say, twenty-four inches, the cooling effect of pipes of the same size, with the same refrigerant if twelve inches apart, would be much greater on the volume of air lying between the tiers. This suggests that, due regard being paid to the total efficiency of the refrigerant available for use in a cooler, the more tiers of pipes there are (where pipes are used) the better. The distribution of the refrigerant among the volume of the air contained in the cooler at any time will be the more advantageous, while the columns or "walls" of air between the tiers of pipes will be reduced in thickness.

In common practice the air enters the cooler at a particular point, say, the point F in Fig. 1, and is driven straight through the cooler, and passes out again by the outlet duct, O, at the other side. There is practically no hindrance or detention of the air in passing through. Obviously the air if held briefly in contact with the surfaces of the pipes, plates or discs, in passing through the cooler, would be more quickly and effectually cooled.

An arrangement which promises such a treatment of the air is shown in Fig. 2. In this case the lines P P P represent thin plates of metal (corrugated), the plates being fixed "on end," with their corrugations vertical and being not more than four inches apart. A thin stream of cold brine would be discharged from a perforated V-trough fixed across the top of each plate. With such an arrangement, the wall of air between each pair of plates would be sufficiently "thin" to admit of an expeditious cooling of the particles of air, while the onward motion of the air would be hindered somewhat by the corrugations, the cooling effect of the plates being hastened thereby. The arrangement of pipes and plates alternately disposed has the same effect. The reducing of the thickness of the columns or "walls" of air in the cooler, and the detention of the air for a longer time in contact with the pipes, plates or discs, while passing through the cooler, will give the most economic cooling of air attainable in ordinary daily practice at cold stores.

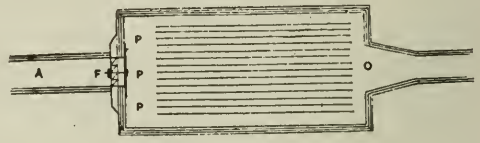

FIG. II.

NATIONAL COAL RESOURCES

A government geologist, M. R. Campbell, has recently prepared an estimate of the bituminous coal deposits of the United States, not including Alaska, and his deductions should do much to quiet the alarmists who are predicting an early exhaustion of our fuel supply. From our present knowledge of the coal fields it appears that we originally had two thousand two hundred billion (2,200,000,000,000) tons, of which we have mined and used about seven billion tons, leaving a reserve of two thousand one hundred and ninety-three billion (2,193,000,000,000) tons. This does not include the anthracite fields, fields of low grade coal, or those of Alaska. Besides the deposits covered by the above estimate more coal is being discovered every year. A recent boring in Colorado passed through 34 coal measures, the lowest seam at a depth of 830 feet being 16 feet thick and of excellent quality. It is safe to estimate the present coal supply of the United States at seven thousand billion tons, and at our present rate of consumption, four hundred and twenty million (420,000,000) tons a year, we have enough to last us seven thousand years.

THE RAPIEFF FLANGE JOINT FOR HIGH AND LOW PRESSURES

By B. C. Batcheller.

Flanged joints for steam, water, air, gas and other fluids under pressure, are usually made tight by bolting a thin, flat gasket of some soft material between the faces of the flanges. Such a joint is shown in Fig. 1. The material used for the gasket is commonly rubber, compounds of rubber with other substances—asbestos, paper, lead, white-lead, etc. We depend upon the compression and flow of the gasket to fill the space between the flanges and friction to hold the gasket in place. Usually the gasket is made broad, covering the entire face of the flange, and the force of the bolts drawing the flanges together is distributed over a large area of gasket. It frequently happens, however, that the bolts must be screwed up very hard to give sufficient pressure per square inch on the gasket to make the joint tight; this is especially true if the faces of the flanges are rough or not parallel. As a result, flanges have to be made much thicker and bolts much larger than required by the longitudinal strain due to the pressure of the fluid alone.

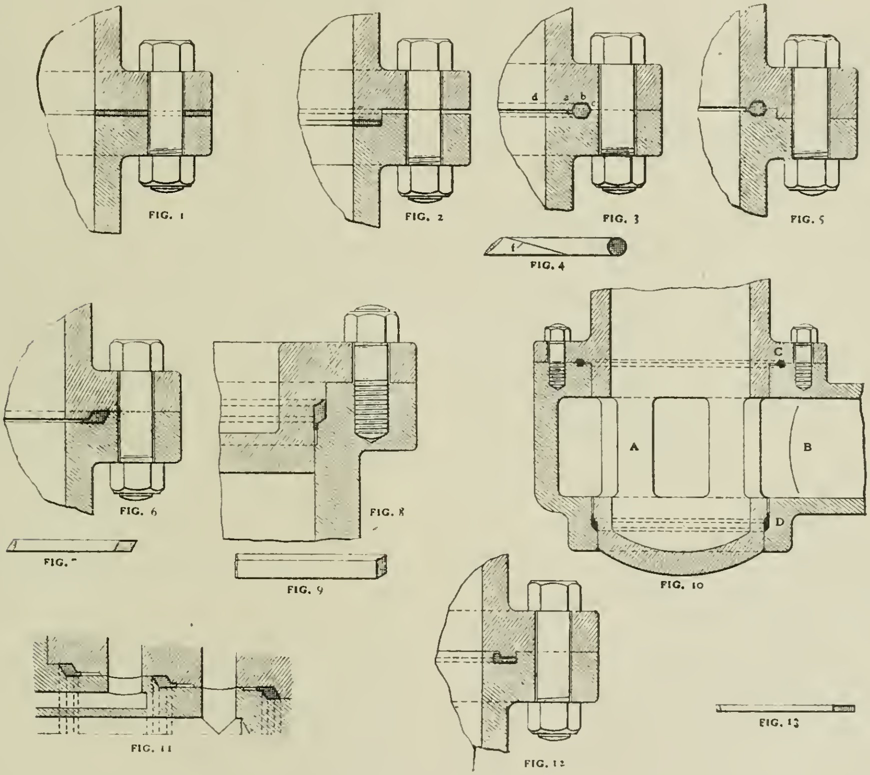

FIG. 1 FIG. 2 FIG. 3 FIG. 5 FIG. 4 FIG. 6 FIG. 8 FIG. 7 FIG. 9 FIG. 10 FIG. 11 FIG. 12 FIG. 13

FLANGE JOINTS FOR HIGH PRESSURES.

In the case of high-fluid pressure it is common practice to increase the pressure per square inch on the gasket by making it narrow and not having it extend across the entire face of the flange. The gasket must be placed inside the bolt circle, and, as a result, if the flanges are not extra thick, there is great danger that the strain of the bolts will break them. A joint of this kind is shown in Fig. 2.

FLAT GASKETS BLOW OUT.

It often happens with high pressures that sufficient friction cannot be obtained between the gasket and the face of the flanges, resulting in the gasket being blown out. This result can be prevented by placing the gasket in a groove or counterbore in the face of one of the flanges with a tongue on the opposite flange as in Fig. 2, but such an arrangement does not overcome the other objections to a flat gasket.

If the two flanges must be at a fixed and definite distance apart, the use of a flat gasket leads to much difficulty, since its thickness depends upon the force with which the bolts are screwed up. One part of the gasket may be softer than another, or there may be irregularities in the faces of the flanges, requiring the bolts to be screwed harder on one side than the other, in which case paralellism between the flanges cannot be maintained.

THE DYNAMITE GUN.

A great deal of ingenuity was expended about 15 years ago in designing the pneumatic dynamite gun, six of which were built for the United States Government, and erected for the defense of our harbors. The guns were eventually consigned to the scrap heap, but there were some features of their construction that deserve to live and have a prominent place among the useful devices of the mechanical arts. I have particularly in mind the method of making the joints in the pipes and castings that were a part of the gun and the gun reservoir. These joints were subjected to an air pressure of 1,000 pounds per square inch in the gun, and 2,000 pounds in the storage reservoir. They were easily and quickly made by ordinary mechanics and were invariably tight. The joints were designed by the late Captain John Rapieff, who designed the gun. One of them is shown in Fig. 3.

Just inside the bolt circle a groove of peculiar shape, *a b c*, is turned in the face of each flange, forming an annular space for the packing when the flanges are bolted together. Into the annular space thus formed, a ring of round rubber cord is laid, and the two flanges are bolted up metal to metal. The cross-sectional area of the grooves is made slightly less than the sectional area of the rubber cord, so that when the flanges are bolted together the rubber is slightly compressed into the form of the grooves and the surplus rubber flows into a narrow space *d*, between the flanges, that is open into the interior of the pipe. This space *d* is made about 1-16 inch thick. The fluid pressure acts against the thin lip of the rubber *c*, tending to force it back, putting the entire ring of rubber under static pressure, and sealing the joint at *c*. Thus the higher the pressure the tighter is the joint, which is not true in the case of a joint with a flat gasket. Since the flanges come in contact, there is no tendency to bend or break them in screwing up the bolts. The bolts need only be screwed tight enough to bring the flanges together, for the tightness of the joint does not depend upon the force with which the bolts are screwed up.

The rubber gasket ring is shown in Fig. 4. It is made from rubber cord that can be bought by the yard and made into rings as required. A splice is shown at *f*, which is made by cutting the cord obliquely and joining the ends with rubber cement. The ring should have the same diameter as the grooves in the faces of the flanges. Rubber cord ½ inch diameter is large enough for the largest joints, and it is not convenient to use cord much less than ¼ inch in diameter. The rubber should be of good quality, soft, and preferably what is known in the trade as "pure gum." When a joint is made in a horizontal pipe, the rubber ring can be held in the groove of one flange by means of rubber cement, while the other flange is being brought up into position. The joint shown in Fig. 3 was used when exact alinement of the bolted parts was not required. In joining together some parts of the gun—for example, sections of the barrel, alinement was important, and to secure that, the joint shown in Fig 5 was used, in which there is a counterbore and tongue.

USING A DIFFERENT PACKING RING.

Another form of the Rapieff joint is shown in Fig. 6, and a section of the rubber ring in Fig. 7. This has some advantages over the joint shown in Fig. 3, since there are only plane and conical surfaces to be machined instead of an irregular shaped groove. The rubber ring can either be molded or be cut in a strip from a flat sheet, and then made into a ring by splicing the ends.

The important point in making all of these joints is to have the section of the space for the rubber between the flanges slightly smaller in area than the section of the rubber before it is put between the flanges, and to provide a narrow space for the surplus rubber to flow into, which must be on the side toward the interior of the pipe. The rhomboidal packings and the conical surface *b c*, in Fig. 3, were made with an angle of 60 degrees.

Still another form of the Rapieff joint used in the pneumatic gun is shown in Fig. 8. This shows a head bolted to a cylinder. The rubber packing ring is not placed between the flanges in this case, but within the cylinder and on the portion of the head that projects into the cylinder. In making this joint the rubber ring should be stretched over the cylindrical part of the head in order to hold in place while the head is being entered into the cylinder. The rubber ring should be wider and thinner than the space it is to occupy after the head is bolted up. Talc powder can be used to advantage on the rubber while sliding the head into place, to prevent the rubber from sticking. Fig. 9 shows the form of the ring before it is inserted.

PACKING TWO SHOULDERS.

With the flat gasket it is practically impossible to make two joints at two shoulders on the same piece and have them both tight, but with the Rapieff joint this problem presents no difficulties. An example is shown in Fig. 10. A lantern casting *A* is bolted by means of a flange to an annular casting *B*. To prevent the escape of fluid under pressure, a rubber-ring packing *C* is used at the joint of the flange, and a rhomboidal rubber-ring packing *D* in the cylindrical joint between the lantern openings. When the flanges are bolted together, both rings are slightly compressed. Fig. 11 shows an arrangement of several packings to separate spaces in the same castings.

The Rapieff joint is not confined in its usefulness to high pressures. In a modified form it has been extensively used in the Philadelphia pneumatic postal tube system, where the air pressure seldom exceeds 5 pounds per square inch. This joint is shown in Fig. 12. A rectangular groove, ½ inch wide by ¼ inch deep, is turned in the face of one flange, and a tongue ⅜ inch wide by 5-32 inch high, is turned on the face of the opposite flange. The outside diameter of the tongue fits the outside diameter of the groove. A rubber ring, shown in Fig. 13, ½ inch wide by ⅛ inch thick, is laid in the groove and the two flanges are bolted face to face. The rubber ring is compressed between the face of the tongue and the bottom of the groove until it has a thickness of 3-32 inch, the surplus rubber flowing into a space provided by making the tongue narrower than the groove. The advantages of this joint are the alinement of the pipe sections and the ease with which a rectangular groove and tongue can be machined.—*American Machinist.*

PREVENTING THE SPREAD OF DUST IN DRILLING SHOT-HOLES

Various attempts have been made to prevent the dissemination of dust during the operation of drilling shot-holes with percussion tools—a water-spray in one case, and oblique currents of air in another—but without much success. The Bonneway collector, illustrated in fig. 1, is said, however, to furnish good results, the dust being conveyed direct into a receptacle near the face, without escaping into the air at all.

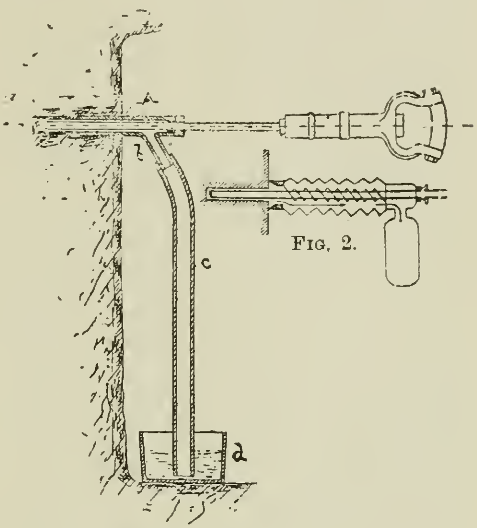

FIG. 2.

FIG. 1.

The collector consists of a tube A, about 10 in. long and 1¾ in. in diameter, which is driven into the mouth of the shot-hole when the latter has been drilled to a depth of several inches. The outer end of this tube is evased and fitted with a collar which presses on a rubber washer forming a stuffing gland for the percussion drill and preventing the escape of dust into the air, whilst at the same time helping to centre the tool. A downward branch *b* of the tube A is fitted with a flexible tube *c*, through which the dust is conveyed to a tub or other receptacle *d*.

Another device invented for the same purpose, by M. Lebacqz, fig. 2, has been in use for some time at the Bihain quarries. It consists essentially of a leather sheath, formed like the bellows of an accordion, to surround the stem of the drill, the one end of the sheath being attached to the drill stem and communicating with a collecting bag, whilst the other end is pressed against the face by means of a spiral spring surrounding the drill stem. The folds of the sheath open and close with the reciprocating movement of the drill, the spiral spring keeping the face end of the sheath tight against the mouth of the hole all the time, the tension of the spring increasing as the hole is deepened.—*Annales des Mines de Beglique.*

CARE OF THE AIR BRAKE PUMP

In fast passenger service an air pump failure is an engine failure, and why the pump should not be given as much care and attention as any other part of the locomotive is not quite clear.

While pumping air into a leaky brake pipe has a tendency to overheat the pump, nearly all of the actual damage which results in a pump failure is done at the engine house at the time the pump is started. Nearly every hostler, shop hand or fireman knows how a pump should be started, but the way it actually is started is very often by opening the throttle wide, whether there is any air pressure in the main reservoir or not, and if the surge of water in the steam end of the pump does not break anything, the piston, after a few seconds, will throw the water of condensation out through the exhaust pipe.

If this same action took place in the cylinders of a locomotive in motion it would probably knock out a cylinder head, but as there is no pressure on the pump piston, other than boiler pressure transmitted through water it cannot knock the top head off. The worst it can do is to wash out all the lubrication of the top head and throw a strain on the bolts holding it, which usually results in a leaky top head gasket, and this robs the pump of the small quantity of oil that can be spared from the lubricator.

When a high air pressure is reached the discharge valves do not lift until the piston is very near the end of its stroke. The stroke shortens somewhat, as the high pressure checks the piston speed, thus giving more time for the reversing gear to operate. In order to be efficient the pump must deliver all the compressed air possible on each stroke. If it does not do this the air which is not delivered to the main reservoir will re-expand in the cylinder and occupy space that should be filled with fresh air through the receiving valves. It seems clear that if the stroke shortens after a certain pressure is reached in the main reservoir there must have been practically no clearance in the air cylinder while the air pressure was low. When the pump is started up fast with no pressure for the piston to cushion on it must strike the heads in order to stop its movement.

When a nut is rusted on a bolt, or drawn so tight that it cannot be loosened with a wrench, a hammer is generally used to pound the nut in order to loosen it and when a pump is started in the manner described there is no reason why the pound of the main piston against the cylinder heads should not loosen the nuts on the bottom of the rod, and the reversing plate bolts. If the end of the rod is burred so that the nuts cannot work off, the piston will be loosened in the air cylinder. It may not occur the first or the second time the pump is started in this way, but it will eventually loosen, and the steel rod will soon cut its way through the cast iron head.

The use of the oil cock and strainer is pretty well known, but there seems to be an impression prevailing in some quarters that the oil cock is a mere ornament, and that the strainer is intended to distribute about a pint of engine oil evenly about the inner walls of the air cylinder when the pump is groaning. There are several styles of oil cups used on the air cylinders of pumps some with an adjustable feed and some with a fixed feed. The former may be fairly well adjusted to feed the required amount of oil but the cup with a fixed feed is very unsatisfactory, as the air cylinder of a pump in good condition requires very little oil, while a pump that is pretty well worn requires much more. As a result of this the cup with the fixed feed partly stops up the ports in the air cylinder of the pump which is in good condition, and does not feed enough to the average pump to keep it from groaning. The piston rod should have a swab, and when the pump is oiled the swab should be oiled. The swab will prevent dirt and ashes from cutting and wearing the rod, and by lubricating the rod packing the swab will save several dollars' worth of packing on each pump in the course of a year.

If the pump is run at an excessive speed about the first disorder will be an overheated pump. This is very expensive. It not only reduces the capacity of the pump by causing the packing rings and valves to leak, but scatters hot and burnt oil throughout the entire air brake system unless the main reservoirs are very large with a good piping arrangement.

When once hot the pump should be run as slowly as possible and kept oiled. Cooling the air cylinder with water is bad practice, as the cylinder is not of the same thickness all the way round and the temperature will reduce unevenly and be likely to warp the cylinder, which would necessitate reboring before new packing rings could be fitted, or it may result in the cylinder having to be thrown on the scrap pile.

A 9½-in. air pump can be run at such a high piston speed that the lift of the receiving valves will not allow the cylinder to be filled with air on each stroke. The partial vacuum thus caused in the cylinder reduces its capacity each stroke.

When the speed of the pump cannot be govened by instruction or discipline, or regulated by common sense, a copper gasket with a reduced opening placed in the steam pipe will prevent an unnecessary number of strokes per minute. Leaky air piston rings allow but a small volume of cool air to flow into the cylinder, and the "churning" of air is one of the common causes of a hot pump.

A blow through the steam end of the pump can develop at a number of places. About the only ones that can be heard on the locomotive are the top head gasket, the steam piston packing rings and a leak on the seat of the main slide valve. Leaks past the main valve packing rings, the reversing valve seat, and past the bushings usually stop the pump. It can then be started by tapping it lightly, and if the feed of oil is increased the pump may not stop again for several hours. When a blow is heard coming from the steam end of the pump it should immediately be given attention.

If a pump starts to pound after it has been in service any length of time and is known to be well lubricated, tight on the bracket and the bracket tight on the boiler, the pound usually comes from an improper lift of air valves, loose main pistons or lost motion in the reversing gear, and should be corrected at once or the pound will result in an air pump failure. When the pump is neglected until it does break down in service very little can be done by the engineer in an attempt to repair it. Cases have occurred where the nuts on the rod worked off in the air cylinder and were replaced while on the road, and where a bent reversing valve rod has been removed and straightened, but the nuts were not put on properly in the first place, and if the valve rod is a neat fit through the reversing valve bushing it cannot be removed without taking off the top head because the plate hammers a shoulder on the rod in a short time after it is put in, and, if a fit at the time, the burr prevents the valve rod from being pulled out. The burr can be avoided by filing the edge of the rod where the plate strikes it, but the repairman does not suppose that an attempt will be made to remove the rod when the engine is out on the road.

Sometimes a broken pump will make a stroke in both directions and stop at the bottom end, and if the steam is shut off and the reversing valve allowed to drop to its lower position, and the steam is again turned on, the pump will make another double stroke and stop at the bottom end.

If there is pressure in the main reservoir and the pump stops with a pound, it is usually due to a nut having worked off the rod in the air cylinder and blocked the main piston; if no pound can be detected it indicates a broken valve rod or a loose reversing plate. If the pump stops at the end of the up stroke with a pound it is usually due to a reversing plate bolt having worked out, although a piece of a broken air valve, or its seat blocking the air piston, will have the same effect. If the pump stops on the up stroke without any noticeable pound the trouble is usually in the top head. When the pump stops on account of insufficient lubrication it stops on the up stroke, with the main valve resting against the cap at the large end, which would appear to be the proper place to tap the pump, if necessary, to again start it.

The pump may become "dry" when it is not being used, and the main valve may have stopped in the opposite position. Opening the drain cock in the lower end of the steam cylinder will show on which stroke the pump has stopped.

When a pump apparently in good condition is reported to be stopping out on the road, and is known to be getting dry steam, and that there are no leaks in the steam pipe, top head gasket or in the pump governor past the steam valve, which would waste oil through the drain pipe, it is good policy to replace the top head of the pump with one known to be in good condition.

When the head is renewed under these conditions, the packing rings in the air cylinder should first be tested by running the pump against an air pressure with the bottom cylinder head removed. The air valves should be examined and cleaned and the packing rings in the steam cylinder tested after the top head has been removed.

This can also be done in case the pump is due to be removed for inspection and repairs and if there happens to be no pump to replace it. In addition to removing the top head to inspect the gasket and reversing plate, particular attention should be given to the thickness of and the opening at the ends of the main valve packing rings; also to the wearing surface of the slide valve and its seat and to the reversing valve and bushing. Intelligent care of the air pump is often the means of avoiding an engine failure.—*Railway and Locomotive Engineering.*

REFRIGERATION IN MINING WORK

Mechanical refrigeration is used for the freezing of loose ground in quicksand soils to facilitate sinking colliery shafts, in running tunnels, in putting in foundations wherever the mass of water is too great to be pumped, or in cases where the removal thereof would damage existing foundations. It is, the especial object here, to consider the various advantages and disadvantages of refrigeration under special conditions, and also to discuss briefly the different types of refrigeration used.

In a general way excavation can be accomplished by the use of compressed air. Caisson work in the laying of .foundations under water, or in excavating tunnels is a typical example. In nearly every case mechanical refrigeration competes with this, and it is largely a question of special conditions and relative efficiency which determines the use of the one or the other.

Certain extreme cases in both developments have such a degree of efficiency that they each practically eliminate the other type. Thus, in excavating where there is a comparatively rapid flow of water, as in the setting of bridge foundations or in tunnels under rivers, compressed air is superior by reason of the fact that the rapidly moving material would carry off a large portion of the partially frozen product and limit the efficiency of the pipes.

On the other hand, the depth at which compressed air can be used efficiently in excavating work is dependent more upon physiological conditions than upon mechanical or engineering ones. Beyond a certain depth the air pressure under which operatives must work becomes so injurious that the shifts must operate smaller and smaller units of time. The necessary loss in compressed air during the process of shifting and in ventilation, which becomes more inefficient in practice with higher pressures, limits the depth at which cassion work can be carried on. This limitation is not present in refrigeration.

The choice of the two processes becomes largely a matter of judgment of the special conditions. In the case of quicksand in a well, a coil of pipes of a somewhat larger internal diameter than the lining of the well is usually sunk, and the quicksand frozen by a circulation of cold brine through the coil. The necessary excavation can then be proceeded with, and as soon as the lining is put in, the circulation of brine is stopped and the coil withdrawn. Facility in the withdrawal of the coil is often accomplished by the injection of steam to render liquid again the material in the immediate vicinity. This process is efficient in small units and is superior to the utilization of compressed air in the illustration given above.

Very small refrigerating machines of a special portable character are available for this work, and the construction of the freezing coils and their utilization is not a matter of serious difficulty. In tunneling the same type of machine can be used, but other methods have been employed. The same can be said in regard to the sinking of shafts through subterranean water beds and quicksand.

There are three processes available for refrigeration in this development. The one, which has been mentioned, is very satisfactory for small work in excavation of any kind, but is superior in vertical shafts. Another uses a cold air blast. This is often done in the driving of horizontal tunnels, and although fairly efficient, the process has been superseded to a large extent by the hydraulic press operation in which a moveable shield or piston is forced forward by hydraulic pressure and the plates fastened on the interior of this piston inside of a sleeve which is slightly larger than the diameter of the finished tunnel.

When cold air was used it was generally produced by an amonia compression refrigerating machine, since the ordinary air compression machine producing refrigeration by the balanced expansion of the compressed air is very inefficient. The air was then driven into the shaft through an inner tube, much like an ordinary hot blast, and the residual air was carried out between this tube and the walls of the tunnel. Sometimes a portable partition was built across the tunnel, and the air of the interior cooled steadily by an iron coil inserted in the chamber and through which a cold brine was passed or in which ammonia was evaporated.

During the construction of a tunnel for foot passengers through a hill near Stockholm recently, this method was employed for driving through about 80 ft. of loose ground which possessed so little cohesion as to render the ordinary method of excavation impossible. After the refrigerator was run continuously for 60 hours the ground was frozen to a depth varying from 5 ft. near the bottom to 1 foot near the top. Under these circumstances the tunnel could be excavated during the day and the refrigeration carried on at night sufficient to permit steady progress with an operation of the machine ranging from 10 to 12 hours per day.

In sinking shafts for mining operations the Poetsch process is the most widely known. In its original utilization the Poetsch process was used to reach a coal bed under a considerable body of subterranean water. This heavy sheet of water gave from a single borehole a flow of 36,000 cu. ft., which rose about 6 ft. above the surface. A stand-pipe was built to stop this flow, but it was necessary finally to divert the water in order to sink the shaft. The process proved satisfactory in this particular development and the shaft was sunk to about 350 ft., with freezing necessary a large part of the way.

However, the device as it existed in the early days possessed many mechanical imperfections, with the result that its deterioration factor was large, and the cost of the original excavation about $160 per ft.

One or two modifications of the Poetsch process exist today, with the object of making the device more efficient, but they are all of the same general type.

In driving a circular shaft the device consists of a series of vertical pipes arranged around the circumference of a circle. These pipes are closed at the bottom, with an interior pipe extending from the top into the outer one to produce a steady flow of the refrigerating material throughout the entire length of the pipe.

In this respect the pipes are similar in construction to several modern types of steam superheaters used for injection into a furnace, and their operation analogous but reversible. These vertical shafts are connected by hollow spokes to a central receiving chamber for the ammonia gas, divided into two parts, forming receivers for the inflowing liquid ammonia and the outflowing ammonia gas, if ammonia is used, or for the inflowing and outflowing brine, if cold brine is the refrigerating agent. This whole device is then attached to a windlass or hoist and sunk into the shaft. Arrangements for cutting out individual spokes or vertical pipes are attached and the two pipes at the top from the central chamber are connected to a refrigerating machine. The device is then sunk into the quicksand, or water, or loose dirt, and the refrigeration commenced. When frozen solid a number of the spokes are disconnected and removed, and the interior of the shaft excavated. Lining is then put in partially between the spokes and the machine driven down farther, the lining being completed above the device. On attaining the lowest depth the machine can be removed piecemeal and the lining completed if desired, or necessary.—*Condensed from Mining World.*

A continuous railway brake has been devised by Messrs. Siemens, in which, while the brakes are applied as usual by compressed air, the valves are controlled electrically, and simultaneously, so as to avoid the dangerous shocks experienced under ordinary conditions. The controlling wires are combined with the air pipes in such a way that a single coupling suffices to complete both the pneumatic and the electric connections between successive trucks.

COST OF VENTILATION PER TON OF COAL MINED

Pennsylvania anthracite mines are, as a rule, decidedly gaseous, and to remove the gases thus generated in the workings, the fans must be run day and night regardless of whether coal is being mined or not; this causes the item of ventilation to be a constant source of expense. All air courses have to be carefully inspected before the miners are permitted to enter the workings. If there is a leakage along any airway the current will be short-circuited to the up-cast. To prevent such defects in the ventilation a force of bratticemen are employed to inspect brattice walls, adjust doors, build stoppings, etc.

In mines such as are operated in the Wyoming and Lackawanna valleys, the care given to ventilation is constant, for it is a matter of vital importance and safety to the men underground. The cost of maintaining an efficient ventilating system is high. The charges against ventilation are made up as follows: (1) Amount of steam used per month; (2) interest and depreciation on the fan and its drive; (3) oil, grease, waste, etc., used on the ventilating apparatus; (4) materials used in building the stoppings, brattice, etc.; (5) wages of brattice men and engineer. The total of all these items amounted to the following at one colliery:

$0.047 per ton of coal mined in 1902
0.049 per ton of coal mined in 1903
0.072 per ton of coal mined in 1904
0.082 per ton of coal mined in 1905
0.078 per ton of coal mined in 1906
0.081 per ton of coal mined in 1907

Engineering and Mining Journal.

A SUBMARINE SPONGE FISHING BOAT

In a recent issue of *La Nature* is described a special submarine contrivance designed by the Abbé Raoul, a vicar-general of the diocese of Carthage, to be used in the sponge fishing along the coast of Tunis.

The vessel is cylindrical with hemispherical ends. It is 16½ ft. long by 5 ¼ ft. diameter, displacing in salt water about 9½ tons, and is operated easily from within by two men. The weight necessary for complete submersion is provided by three tanks holding 140 gallons. Two of these are constantly full of water while the third, smaller than the others, placed in the center, is filled by the water pressure for descending and the water is expelled by compressed air when it is desired to rise to the surface. A leaden safety weight attached to the bottom may be released in case of necessity, when the boat will rise rapidly.

It is propelled by two oars of steel, fitted with slats which open when moved through the water in one direction and close when drawn the other way. They have spherical joints in the shell so that they may be moved in all directions.

The fishing apparatus consists of a rod projecting from the bow through a spherical universal joint. This rod bears at its end a pair of cutting pliers which detach the sponge, hold it and deposit it in a basket suspended just above it. The sea bottom is lighted by a cluster of electric lamps and the fishermen observe operations through strong windows. Electricity for illumination is furnished by a storage battery, and there is a telephone communicating with the surface.

A NEW TOUCH OF COMPRESSED AIR IN DENTISTRY

The porcelain inlay has been known in dentistry for a little more than fifteen years, and during this entire period dentists have been endeavoring to find some method of adapting the process to gold, which is the only known material suitable for filling a tooth at the biting edge, being malleable and ductile, while porcelain is brittle and breaks under pressure. It has now become possible to use the gold inlay, by means of which the patient is relieved of any but the least handling of a tooth under treatment, after the cavity has been prepared for the gold that is to fill it. Instead of hammering in the gold, as was the only process until a few months ago, the dentist now takes a wax impression of the cavity, from which he constructs a mold into which the gold is poured in a molten state, the resulting cast being the inlay, and of course a facsimile of the wax model. The inlay is slipped into the cavity, which it fits exactly, and is secured with cement. It was found impossible, however, to cast a gold inlay that would not shrink until the present process was perfected whereby pressure is applied to the metal in the mold by means of compressed air.

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AND EVERYTHING PNEUMATIC
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COMPRESSED AIR LEAKAGE

Those who read the letter of Mr. Tecumseh Swift on the above topic in our April issue, (and all should have read it) will be interested in the following, which fully explains itself. It is from the second quarterly issue of *Reactions,* published by Goldschmidt Thermit Company. We would only ask *Reactions* to tell us of *any* compressed air pipe line which has been welded and made air tight by the Goldschmidt Thermit process. The article referred to is here reproduced in full:

According to a reader of the monthly magazine COMPRESSED AIR, we are guilty of the crime of manufacturing facts and figures to make our process of pipe welding appear in a favorable light. The gentleman in question, whose name is Tecumseh Swift, quotes our article at length and comments on it as follows:

"The animus of this," (our facts and figures) "appears in the last sentence of the article:"

'It is to counteract these losses that many concerns are now butt-welding the pipe-joints in their compressed air and refrigerating pipe lines, thus producing a continuous line of pipe in which leakage is entirely impossible and the cost of maintenance eliminated.'

'Now, as to the loss by leakage. I have reason to believe that the above assumptions are exaggerations and that it is not so difficult nor so unusual as here represented to make piping airtight. The capacity of the usual air receiver represents about one minute's output of the compressor with which it is associated, and the piping capacity will not average any more than that of the receiver, or altogether it might be said that two minutes' working of the compressor would fill the entire system from atmosphere up to full working pressure, and then when the compressor is stopped at night and in the morning the air pressure is still found there, which is the not infrequent occurrence, it is easier to realize how little air has leaked away than how much.'

'A handy, cheap and reliable welding process, which Thermit undoubtedly is, would, for compressed air practice, need to be accompanied by an equally handy, cheap and reliable *unwelding* process, for *all* air piping is not permanently installed, and the butt-welding of straight piping would not in any case eliminate the possible leakage, which occurs not in the run of the pipe, but in valves, stuffing boxes and other places where Thermit would not apply."

Now, we do not know who Mr. Tecumseh Swift may be, or what his qualifications are to pose as an expert in compressed air matters, but we are quite sure that we have some excellent reasons, backed up by excellent authorities, for disagreeing with him. Taking first, his statement that our estimate of the amount of leakage in a compressed air plant is exaggerated, we wish to quote the following from an article appearing in the April 23rd issue of the *American Machinist*, page 633: "A coal company told an erecting engineer that one of his firm's compressors which had been running some time, was not delivering its rated capacity. The machine was rated at 44 cubic feet per revolution; its normal speed was 70 revolutions per minute, thus giving a free air capacity of 3,080 cubic feet per minute. The compressed air was used mostly for driving pumps. From figuring the capacity of the air cylinders of the pumps, one of the coal company's men had concluded that the compressor was not pumping nearly its rated capacity. The erecting engineer got permission to make a test. One Sunday the pumps were all shut off and it was found that it required 32 revolutions per minute of the compressor to keep the air pressure up to 80 pounds; thus showing a leakage of 1,400 cubic feet of free air per minute, requiring at the steam end of the compressor about 120 indicated horse-power."

The above is from an article prepared by Mr. H. V. Haight, Chief Engineer Canadian Rand Co., and Mr. B. C. Batcheller, Chief Engineer of the Pneumatic Service Co., in which they recommend the use of special fittings for high pressure air installations.

We do not doubt that there are some plants where, as Mr. Swift states, leakage is reduced to a minimum, but we were speaking of the average plant, where, as a general rule, very little care is exercised in fitting up the pipe line.

Now, in regard to Mr. Swift's statement, that a "handy, cheap and reliable welding process" should be "accompanied by an equally handy, cheap and reliable unwelding process;" we claim again, that he misinterprets the general tenor of our remarks. While we were not speaking of the special installation with white enamel machinery and nickel plated fittings, neither were we speaking of temporary plants, like contractors' plants, which are constantly undergoing changes. We believe that there are a large proportion of plants in this country where compressed air is used, and where the piping, once installed, will remain in place. At least it should be the object of a plant to place the piping so that, when once installed, it will not require to be changed. The joints could then be welded, and a considerable saving effected in the cost of leakage, which would be limited to valves and cocks which are very easily made tight.

THE DRILL CONTEST ON THE RAND

Those who read the account in our May issue of the South African Mines Drilling Contest will be interested in the following letter addressed to the editor of the *Mining and Scientific Press* in correction of certain misconceptions of a correspondent:

Sir—In your issue of March 28 there appeared a letter on this subject written by one who signs himself "Mine Manager." The gentleman appears to have overlooked the fact that 40 per cent. of the holes drilled in the South African stope-drill contest were upcast holes. He says: "The entire contest was based on drilling inclined holes in a perpendicular face." This is not true, for out of the whole four days which each drill had to run, not over an hour was spent by any competitor in drilling inclined holes in a vertical face. This is certainly a very small part of the four days, and furthermore the inclined holes in question were upcast and not downcast holes.

The conditions of the contest were fixed by a joint committee (of which the writer had the honor of being a member) consisting of mine managers, engineers, and drill-manufacturers. Every effort was made to make the conditions equally fair for every type of drill and at the same time to prove the relative drilling power of each type under the different mining conditions found in the numerous mines of the Rand. The entries included six drills of the percussive type, three of the hammer type with air feed, one hammer drill with a screw feed, and two of the Gordon type.

It was on just such upcast holes as "Mine

Manager" considers ideal that the winning drill, the Gordon, did more than double the work of any other competitor. Numerous rules were made in order that no question might arise as to the justice of the results, but the main points were as follows: All holes must be over 36 in. deep; all holes must bottom or finish large enough to take the standard sticks of explosive; all holes were to be drilled approximately as indicated by the judges before the work started.

Each day's work on the surface consisted in drilling for one hour in each of the test blocks, three hours being spent on downcast holes and one hour on flat and upcast holes. Underground, one day was spent on drilling downcast holes in an overhand stope and one day in drilling upcast holes in an underhand stope. L. C. Bayles.

AN INTERNATIONAL CONGRESS OF REFRIGERATING INDUSTRIES

Announcement is made of the first International Congress of the Refrigerating Industries, to be held in Paris, September 17 to 23, The French committee has invited other countries to participate. The United States Government has accepted the invitation, and delegates will be appointed to represent this Government. An American committee has been formed in part, having the following officers: President, Homer McDaniel, Cleveland, Ohio; vice-president, John E. Starr, 258 Broadway, New York; treasurer, John S. Field, Chicago, Ill.; Secretary, J. F. Nickerson, 315 Dearborn street, Chicago, Ill. The purpose of the congress is to bring together the leading experts and representatives of the various industries and enterprises in all countries in which refrigeration is used for facilitating the preservation and transportation of food products. The congress is divided into six sections, as follows: Section 1, Low Temperatures and Their General Effects; Section 2, Refrigerating Appliances; Section 3, The Application of Refrigeration to Food; Section 4, The Application of Refrigeration to Other Industries; Section 5, The Application of Refrigeration in Commerce and Transportation; Section 6, Legislation. Arrangements have been made for a documentary exhibit and a display of plans, models and small appliances. American manufacturers are invited to send exhibits. Of these, particulars may be obtained from the secretary of the American committee.

THE SAND BLAST IN THE FOUNDRY*

CLEANING CASTINGS.

On the subject of cleaning castings, it may be said that, until quite recently, this work has been done by means of pickling and tumbling; both of these methods are well known and reliable, but more recently there has been a strong demand for cleaning by means of the sand blast.

It is thought by many that a sand blasted surface will hold paint more firmly than the surface cleaned by pickling. Some two years ago, our attention was called to the use of sand blast tumbling barrels. These are adapted to cleaning comparatively small castings.

SAND BLAST.

This apparatus includes a supply of compressed air at 15 to 20 pounds pressure and an elaborate exhaust system for the continuous supply of sand and for the removal of fine dust. This fine dust has been difficult to control, but this has finally been accomplished by passing it through a wet scrubber, as it is called. This scrubber consists of a stack or trunk about 7 feet square and 25 feet high. This stack stands in a water-sealed base and is fitted with a series of wooden racks or slats, over which a flow of water is circulated by means of a centrifugal pump. These racks are so placed as to break up the passage of air through them. They offer a very large area of wet surface to the dust-laden air, and in passing through them the dust is practically all deposited on the wet racks and is washed to the bottom, from which it is removed from time to time. This wet scrubber receives the dust, not only from the sand blast barrels, but also from the regular tumbling mills and, while it is not strictly speaking an essential part of either, the total amount of dust discharged is so great as to constitute a serious nuisance if blown into the open air and, except in any isolated situations, some efficient dust separating device must be provided.

The work done by the sand blast barrels is very satisfactory in both quality and quantity, and the direct labor cost is no more than the cost with ordinary tumbling barrels, but the cost of installation and the cost of maintenance are both high. The installation of the sand blast barrels must, therefore, be justified by quality of the work done, rather than by its cost.

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*From a paper by W. T. Hatch, May Meeting N. E. Foundrymen's Association.

SAND BLAST FOR LARGE CASTINGS.

During the past year, the question of applying the sand blast to machine frames and other castings too large for the barrels was taken up—after repeated postponements on account of the dust nuisance, which, within the writer's observation, has more than balanced its advantages.

The question was not as to the merit of the sand blast, but as to the feasibility of taking care of its dust and dirt, and operating it under fairly comfortable conditions for the operator. The arrangement of this installation will be of interest, because we have made it successful to this extent.

The sand blasting is done in a room built within the cleaning room proper. This room is 15 feet square and 8 feet high. The work to be cleaned is suspended from an overhead tramrail with an electric hoist

A slot in the roof of the room allows for the proper placing of the piece to be sand blasted, and the roof of the room protects the hoist from any injury. The room is ventilated by means of a Sturtevant steel plate exhauster with 18-inch suction and discharge connections. This exhauster is run at 1,260 revolutions per minute, and gives a free circulation of air through the room. Air is admitted to the room from the opposite side and as near to the operator as possible. The intention is to supply the operator with ample fresh air and to draw the dust away from him. The space between the operator and the dust outlet on the opposite side of the room is some 10 feet, and gives time for the sharp sand to fall to the floor, so that only the light floating dust is drawn out of the room. The sand can thus be easily shoveled up and used over repeatedly. The dust is discharged through a wet scrubber, similar in principle to the one used for collecting the dust from the sand blast and other tumbling barrels. The fitting up of this sand blasting room, including its exhauster, its motor and wet scrubber, has been quite an expense, to say nothing of the power required to operate the sand blast and the exhauster; still the quality and quantity of work done with this apparatus are very satisfactory, and if it be admitted that sand blasting is necessary, I believe our installation must be considered a success. As in the case of the sand blast barrels, however, the cost of the installing, operating and maintaining the sand blast apparatus is high, and the quality of the work done, rather than its cost, must be the reason for its adoption.

REPAIRING A SIX FOOT STEEL MAIN UNDER THIRTY FEET OF WATER*

The pipe repaired supplies Jersey City with water. The portion under the Hackensack River is 11-16 in. riveted steel pipe 6 feet in diameter. When this pipe was placed it was brought to the river bank in about 28 ft. lengths each made up of four sheets. These were connected upon a staging carried across the river on floats. The pipe as connected was enclosed in reinforced concrete rings, which were made in forms and then slipped over the pipe and afterwards grouted, thus making a continuous concrete covering, the weight of the whole being just sufficient to sink it. This completed pipe was then sunk in a level trench which had been dredged in the bottom of the river. Shortly after the pipe was lowered and filled with water and before the ends were connected to the line it was discovered that a break had occurred and it was decided to build bulkheads at each end, force the water out by air pressure and make an examination from the inside. It was discovered that a plate had parted, making an opening about seven-eighths of the circumference of the pipe, the widest opening, 2½ in., being at the bottom. This was repaired by putting a complete ring of steel plate inside the pipe. The ring was made of five plates and secured in place by stud bolts.

A year or so later, or in 1904, another break in this pipe revealed itself by the sound of the rush of water which was plainly audible when passing over the river in a boat. A diver could discover nothing of the leak but the noise; the leakage, however increased until the loss was between five and six million gallons daily.

In the fall of 1907 a diver again employed reported that the stream coming from the pipe was of sufficient velocity and volume to force his body to one side when he passed in front of it; that there was a hole in the concrete covering on the side of the pipe about 10 in. square, and that the velocity was so great that he could not feel of the pipe to determine the character of the injury to the steel plates. The diver's description of the leak and the quantity of water being lost was evidence enough that repairs should be made at once.

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*Abstracted from a paper by A. W. Cuddeback read before the American Water Works Association.

A compressed air plant of sufficient capacity to handle the job, together with the necessary boiler power to operate it, was secured and set up on the west bank of the river. At about 400 ft. west from the break a 48-in. tee had been placed in the line when it was built, with a main line 48-in. valve on either side of it and a 48-in. valve on the tee; also a main line 48-in. valve on the east side of the river. This afforded means of getting into the pipe without cutting the main line. An air lock was obtained and fitted to the flange of the valve in the tee, the plant set up and got in working order. About 200 ft. east of the 48-in. branch, which afforded a means of entering the pipe, and therefore 200 ft. nearer the river and the break, was a manhole. As soon as the pressure was off the main line the cover was removed from this manhole, and another cover which had been previously fitted with a 3-in. tapped opening, through which a 3-in. nipple was screwed, was put on in its place. From this manhole a line of 3-in. screw wrought-iron pipe, which had been previously prepared in suitable lengths, was then connected and carried down the 72-in. pipe toward the break as the water was forced out of the 72-in. pipe through the break by the pressure of the air. This 3-in. pipe acted as a discharge for the water after the break had been stopped up, and no more water could be forced out that way, and proved of sufficient capacity.

On Dec. 1, 1907, the first move toward getting into the pipe to determine the nature of the break was made. The main line valve on either side of the river was shut down, thus isolating the river crossing, which is about 1,000 ft. in length. These valves were finally closed at about 2 P. M. After these valves were closed the 48-in. valve on the branch was opened and as much water allowed to run out this section of pipe through the airlock as would do so. Then the airlock was closed and the air compressor was started. No difficulty was met in forcing out the water until it got to such a level in the pipe that the air would escape through the top of the break. As soon as this point was reached the air escaped with such rapidity that no further progress could be made toward forcing out the water. Several schemes were tried before it was finally possible to plug up the crack sufficiently to hold the air and force out the rest of the water. It being in the winter time, it was exceedingly unpleasant to wade in water up to one's neck and by hand plug up the crack with clay. Large quantities of waste and gasket yarn were floated out on boards in the pipe and the crack partially plugged in this way, but this method was found to be slow and unsatisfactory. Finally the foreman in charge of the work waded out in the water in a diver's suit and succeeded in plugging up the crack with clay, after which there was no further difficulty in forcing out the water sufficiently to allow men to enter and examine the pipe thoroughly. It was discovered that the pipe had cracked about three-fifths of the way around, the crack being on top and open at its widest part from ⅜ in. to ½ in. This work took all Sunday afternoon, Dec. 1, all day Monday, the 2d, and up to 2:30 P. M. on the 3d, when it was possible to make an examination and determine the nature of the rupture in the pipe. At this time Jersey City was getting short of water and so the water had to be turned through this 72-in. pipe again, in order to maintain the supply, which was done at 6 P. M., Dec. 3.

The time for making repairs being limited to practically a 48-hour period, it was seen that it would be utterly impracticable to repair this break in the manner in which the first break had been fixed. It was concluded to put an internal ring in the pipe, making the ring, or sleeve, of steel plate. It took three plates 2 ft. wide by 6 ft. long. It was thought that the ends of these plates could be bent inwards at right angles for bolting together. but it was found that the steel would crack, so angle irons were riveted to the plates instead. The ring when bolted together fitted the interior of the pipe loosely and set-screws were put in at different points to locate the ring with an equal space all around.

Several materials were considered for filling between the sleeve and the pipe. A patent cement which will expand upon setting was one of the materials, but it was rejected as a filling, because of the time necessary for its setting, which in that position would have been at least 24 hours before it would have been safe to let water come in contact with it. Lead in its usual form was rejected, because of the impracticability of pouring the joint completely and the fact that, even if it were possible to pour it, it could not be calked its entire depth. Lead wool was finally decided upon. This was selected, on account of the felicity with which it could be handled, the fact that it could be placed in the presence of water and that it could be calked in the entire depth of the joint.

After the first examination of the pipe was made the actual starting of repairs was delayed for several days until arrangement to supply Jersey City with water while the conduit was out of service were made, and the repairs proper were begun on Dec. 19, 1907. The water was turned off at 8:45 A. M. on this date, and the pipe finally emptied below the position of the break, the necessary tools, sleeve, materials, etc., gotten in the pipe by 6 P. M. During the night the sleeve was placed in position ready for the filling material.

After the sleeve was placed in position the center of the joint around the row of circumfrential rivets of the pipe and where the crack was located was thoroughly calked with ordinary gasket yarn smeared with clay, in order to prevent the water working in and getting around the layers of lead wool which were to follow and to act as backing for the first layer of lead. Then the filling was continued from each side with lead wool and thoroughly calked to within about 2 in. of the outside edge of the sleeve. This outside space was filled with strips of solid lead, 3 or 4 ft. long, which had been poured in molds the thickness of the joint and thoroughly calked. The work of calking in the lead wool was begun at 6 A. M., Dec. 20, and carried on continuously until finished, and the water again turned on about 7 P. M. of the same day, making a total time that the conduit was out of service approximately 36 hours. The pipe was tested for leakage when the water was turned on and found to be tight.

Special homemade calking tools were used in placing the lead wool in the joint. The men who actually made the repairs worked in two shifts of five men and foreman for each; two hours in and two hours out of the conduit, the same men working in this way from start to finish of the job. The men were all from the regular working force of the company and were selected for their known qualities of endurance, and to their faithfulness is due very largely the successful completion of the job in so short a time.

SOME TUNNEL SCHEMES

A TWELVE MILE TUNNEL.

It is reported that the Great Northern Railroad (Hill system) is preparing to bore a tunnel about twelve miles long through the Cascade Mountains, or the main part of that range. Two large forces of men are already engaged near Leavenworth, Wash., getting material together to build three large dams in the Wenatchee River to develop power with which drills and machinery are to be operated It is also stated that the Great Northern has arranged for the development of electrical power from the Chelan Falls for the operation of trains through the present tunnel in the Cascade Mountains, and later through the twelve-mile bore. This tunnel project has long been openly considered by the Great Northern Company, and engineers have thoroughly investigated and approved of the plan. Such a tunnel would give the road the most direct line through the Cascades down to Puget Sound waters, and also dispose of the tremendous mountain climb which must now be made.

A SIX MILE TUNNEL.

It is stated by Mr. Julius Kruttschmitt, general director of maintenance and operation of the Harriman System, that the 36,000 foot tunnel under a spur of the Sierra Nevada will be built in the near future. All surveys for this tunnel were completed some time ago under the superintendence of Chief Engineer Wm. Hood. The boring will be carried on not only from each end but also from several shafts, so that it is expected that the entire work can be done in three years. This tunnel will reduce the climb by nearly 1,000 feet and also effect a considerable saving in time. The total outlay is estimated at $10,000,000 which will be more than warranted by the reduced cost of operating.

SPIRAL TUNNELS.

An interesting piece of railroad engineering is now in progress near Field, British Columbia, on the main line of the Canadian Pacific Railroad. The original grade turn is 4.5 per cent., and it takes three and sometimes four locomotives to push the transcontinental trains up the hill. The Kicking Horse Canyon is too narrow for loops, so a new line is being built which will cross the river and cut right into the solid mountain with a tunnel 16 ft. wide, 24 ft. high and 3200 ft. long which will make a complete spiral, or, more strictly, a helix, emerging at a point 70 ft. higher than the entry. By means of this and other tunnels the grade of the line in this neighborhood will be reduced to 2.2 per cent.

The originator of the spiral tunnel, William H. Cilley, an American engineer, by this means found a feasible grade up the Valley of the Rimac for the Peruvian Central Railway. The method was later employed for a similar purpose in the St. Gothard tunnel in the Alps.

THE AUTOMOBILE IN DEVELOPING MINING

Few people realize the important part automobiles play in modern mining affairs. Those who have been reading of recent boom camps in Nevada know that the automobile is one of the almost indispensable factors in the quick development of new districts. New mining camps are not generally found along railway lines and to reach them from the nearest railroad point sometimes requires several days' travel under tiresome difficulties and discouraging annoyances. Now, as soon as a new camp is discovered or a rich strike is made which causes a stampede, a line of automobiles is immediately established and travelers are taken from the railway train right into the camp with little less conveniences than are afforded on the best trains and in about as quick time.

As a factor in the rapid development of mining districts in the west the automobile is regarded as of great importance. Capitalists and their representatives have little time to waste in life and unless the showing is of the most encouraging nature numerous properties situated in districts remote from railroads, are passed by. Since the advent of the automobile in Butte nearly all of the principal mining districts of Montana have been brought within a day's trip of the big camp where mining investors and engineers make their headquarters while in the state. Hardly a day goes by without some local mining man taking a party of visiting engineers, experts and capitalists to inspect a mine in some remote part of the state and the trip is made one of pleasure as well as business.—*Butte Copper Age.*

ELECTRICITY AND COMPRESSED AIR IN MINING*

For driving the ordinary reciprocating air-compressor, the electric motor does not show up at all favourably. The steam-driven compressor has a very high efficiency, a good deal higher than that of a steam engine driving a rotating shaft; its excellence in this respect being due to the fact that a great part of the work transmitted from steam to air cylinder passes direct along the piston rod and not through the crank pin at all. This advantage is of course lost if the whole power used in compressing has to come from the crank shaft as would necessarily be the case if an electric motor were used to do the work. If air-compressing is to be done by a motor, a rotary compressor suggests itself, but a very high efficiency does not seem probable in this direction. Some tests described by M. A. Barbezat on a Rateau steam turbo-compressor, built by Messrs. Brown Boveri, of 400-horse power and delivering air at 71 lb. pressure, give an efficiency of about 70 per cent.

It has long been known that the transmission and distribution of compressed air for mining purposes is, in practice, extremely inefficient; but the full extent of the losses, due to wasteful use of air, leakages and inadequate distribution pipes (which are often under the control of unskilled men) has only recently been realized. The investigations of Mr. Hutton and Mr. Schweder have now established the figure of 28-i. h. p. in the steam cylinder of the compressor as that necessary to keep each 3¼ in. drill properly running. Of this from 5 to 6-horse power gets far enough to be indicated in the drill, and, according to Mr. Schweder, only 1.7-horse power actually reaches the rock.

The ease with which electricity can be dealt with, and the fact that a switch-board instrument can at once indicate the presence of leakage, have caused proposals to be made to distribute power electrically to small motor-driven compressors underground. This, however, only goes part of the way to meet the difficulty, and many attempts have been made to produce an electric drill; but, as might have been expected, no purely electrical percussion drill seems to have proved satisfactory. The Temple, so-called electric drill (The Temple-

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*From a paper read before the Institute of Mining and Metallurgy by H. J. S. Heather.

Ingersoll Electric Air Drill) seems to get nearest to solving this problem. This is really a pneumatic drill driven by the reciprocating motion of two plungers operated by an electric motor. There are no valves between the drill itself and the two air chambers, and no clearances to be filled with air at every stroke. Comparative tests have been made by Mr. C. A. Chase, general superintendent of the Liberty Goldmining Company, Telluride, Colorado, on 3¼ in. air drills working at 100 lb. pressure, and the nearest corresponding Temple drill, the actual drilling done by the latter being slightly more than that by the air drills. Mr. Chase found that the air drills took 25-horse power each at the motor driving the compressor, thus agreeing fairly well with the results above quoted, and the Temple drills 5-horse power each. These figures are said to have been confirmed by Mr. Barnes in the Yak Tunnel at Leadville.

The author has not had an opportunity of seeing the Temple drill, and the particulars he has received do not go sufficiently into detail to enable him to express a final opinion, but the arrangement seems to him a most promising one, and as, wherever applicable, it should reduce the present costs of power for drilling by at least one-half, it certainly deserves to be closely looked into.

NOTES

In the past quarter of a century we have seen the air compressor rise from the status of a mere curiosity to an immense factor in economical engineering, and why? Because engineers have put energy, skill and money into the problem, and recognizing the necessity for volumetric efficiency, they have used every device to make the air-pump handle every possible ounce of air.—*F. A. Rider.*

Glacier ice is now delivered to some of the larger consumers of Lyons and other cities of Europe. There are so many railways in the Alps at present that it has been found profitable to gather this ice and transport it to the cities, where it is preferred to other ice because of its hardness and lasting qualities. This ice is blasted and mined in the same manner as stone is quarried.

At Rio Tinto, Spain, where pyrite smelting is now being done (in six furnaces), Parsons turbine blowers are used. Operated in tandem, they deliver air against 60 oz. pressure, and are said to be of high efficiency, economical, and satisfactory in all respects save that there is an extraordinary and enormous noise at the intake of the air, which is next to unbearable to persons having to work anywhere near-by.

Cutting the price down dangerously near to the actual cost basis when a little artificial lull comes along is very poor policy for the operator who wants to stimulate prosperity. Doing business without a profit is a thankless task, and one calculated to make the man who indulges in it miss opportunities for getting good business later.

In the matter of equipment don't overlook the fact that elevating and conveying devices are the cheapest carriers for all kinds of material, and that human pack-mules are the most expensive as well as the most refractory elements that the manufacturer has to contend with.

Coal by weight develops eight times as much energy as dynamite, and dynamite costs forty-five times as much as coal. One dollar's worth of coal would then develop as much energy as $360 worth of dynamite.

The H. K. Porter Company, Union National Bank Building, Pittsburgh, has recently taken an order for six of its 18-in. gauge air locomotives for gathering purposes in the mines of the Homestake Mining Company, Lead, S. D.

A five-inch ammonia pipe at the Manhattan brewery, Chicago, burst recently, killing two men who were calling on the engineer and seriously injuring the latter. The men were overcome by the fumes before they could reach a place of safety.

The protection of steel reinforcement by bedding in concrete has been investigated by the National Physical Laboratory of Great Britain, the tests showing that both bright steel bars and those bedded in the concrete without removing the scale from them are thoroughly protected from rust, even though the concrete is covered with water several times a week for a year and afterwards left in the open air for months.

A paint has been prepared to indicate excessive heat in machine parts. It is described as red when cool or normal, but when the painted part becomes warmer than it should be it turns black, the red appearing again when the temperature falls. The paint is said to be made by mixing mercuric iodide and cupric iodide with distilled water in proportions which vary with the temperature which it may be desired to indicate.

Prof. Hallock lectured recently before the Chemists' Club, in New York City on "Blaugas." This is liquid illuminating gas discovered by Professor Blau, of Germany, and while it is not manufactured in this country, it has found an extensive use in Germany, where it is sold by weight. A 22-lb. cylinder contains enough liquid gas to supply a 50-cp burner for four months if used four hours a day. Very small copper tubes, about the size of an electric light wire and just as flexible, connect the burners with the reservoir.

Paris underground railways now open for traffic have a length of 32 miles, out of a total authorized of 57 miles, work being in progress on all lines which are not yet in operation. The Metropolitan scheme includes two sets of rails parallel to the Seine, and serving the traffic of the central portions of the city, a circular line surrounding the city, and situated between the central quarters and the fortifications, occupying somewhat the position of the outer boulevards; and, lastly, two transverse lines at right angles to the course of the river. The portions of this system now in operation carry an average of 350,000 passengers daily. The other concession, called the North and South Railway, crosses Paris transversely from north to south, and has a total length of about seven miles, all of which is now under construction.

Considering the great amount of dynamite used in the mines in Butte there are comparatively few accidents from explosions or blasting. It is estimated that 15,000,000 blasts are set off in Montana each year. Careful estimates place the number of blasts in the Butte mines at 35,000 per day when the mines are operating at full capacity. About 4,800,000 pounds of explosives, 120 carloads, are used each year in Butte and the cost aggregates $720,000. Candles are sometimes used in lighting the fuse and this practice helps to swell the enormous amount of candles consumed in the big mining camp. It is estimated that five carloads or 1,000,000 candles are used each month in the Butte mining district, or 12,000,000 a year, at a cost of about $192,000.

A novel gas engine starter has been developed by the Oil City Gas Engine Co., consisting of a flash boiler furnishing superheated steam at high pressure which may be used in a gas engine in the same manner that compressed air is used for large engine units. The boiler is of the coil type of small capacity, and is heated by a large gas burner. When in operation, the coil is heated to a red heat, and then a small quantity of water is injected by a hand pump. This water instantly flashes to steam of from 400 to 500 pounds pressure, and is then admitted to the engine cylinder. The first heating of the coil will furnish sufficient steam for turning the crank a number of revolutions, and if the engine then should fail to get in operation, a second heating of the coil will give another number of turns, and so on. A Safety valve set at 500 pounds protects the device from excessive pressure.

The transportation of coal from the landing piers at the Genoa, (Italy) wharves has been considerably increased by the opening of a tunnel, cut through solid rock, and leading to the adjacent City of Sampierdarena. Coal trucks drawn by mules, which will hereafter pass through this tunnel, will supply fuel for the consumption of the different factories lying between the City of Genoa and Voltri on the west and Bolzaneto on the northwest. The dimensions of the tunnel are: Length, 275 meters (902 feet); width, 15 meters (49.2 feet); height, 8 meters (26.2 feet). Constructive work was begun on August 1, 1907. Trucks transporting coal save a long ascending passageway, involving more than an hour's time. Some 600 carloads, averaging from 2 1-2 to 3 tons of coal each, will pass through the tunnel daily. Its mouth begins on the pier, just under the fortress of San Benigno, and ends at Sampierdarena.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

MAY 5.

886,353. AIR-PUMP. Orris J. Darling, Detroit, Mich.

886,390. SIPHONIC DREDGE. William J. Moninghoff, Philadelphia, Pa.

886,402. CUSHIONING DEVICE FOR PISTONS. Otto S. Pike, Malden, Mass.

886,428. DUPLEX AIR-PUMP. John Shourek, Pittsburg, Pa.

886,489. AUTOMATIC SHUT-OFF FOR PENUMATIC TUBES. Edgar Flint, Toronto, Ontario, Canada.

886,552. GAS-PRESSURE GAGE. Walter Thomas, Vancouver, British Columbia, Canada.

886,615. PNEUMATIC RECUPERATOR FOR RECOIL-GUNS. Otto Lauber and Norbert Koch, Essen-on-the-Ruhr, Germany.

886,699. ACETYLENE-GAS GENERATOR. Joseph Heaton, Hampton Station, New Brunswick, Canada.

886,834. PRESSURE-CONTROLLER. Andre Michelin, Paris, France.

887,051. FLUID-FEED SIDE-INLET DRILL-BIT. John H. Wiest, Boulder, Colo.

MAY 12.

887,095. FLUID - PRESSURE - OPERATED TOOL. Charles H. Johnston, Chicago Heights, Ill.

887,199. EXPRESSION DEVICE FOR PNEUMATIC MUSICAL INSTRUMENTS. Eugene de Kleist, North Tonawanda, N. Y.

887,361. ELASTIC-FLUID TURBINE. Ernst P. Wagner, Charlottenburg, Germany.

887,363. ROCK-DRILL. Governor D. Warren, Cripple Creek, Colo.

887,380. ELASTIC-FLUID TURBINE. Charles W. Dake, Grand Rapids, Mich.

887,388. VACUUM POWER-HAMMER. Louis Golly, East Orange, N. J.

887,467. METAL-CUTTING BLOWPIPE. Cyrille Delcampe, Bridgeport, Conn.

887,491. ACETYLENE-GAS GENERATOR. Charles W. Metcalf, San Diego, Cal.

887,505. AIR-CUSHION AND AIR-COMPRESSOR FOR AUTOMOBILES AND OTHER VEHICLES. Wesley H. Nelson and Lee W. Galloway, Norwood, Colo.

887,571. AIR-COMPRESSOR. Frederich B. Babee, San Jose, Cal.

887,608. APPARATUS FOR RAISING AND LOWERING LOADS. Louis E. A. Duflon, St. Petersburg, Russia.

1. In an apparatus for raising and lowering loads, the combination with an elevator conduit and a compresesd air conduit of a plurality of loading cylinders adapted to successively register with the elevator conduit each provided with an air passage to connect the elevator and air conduit, means to vent the elevator conduit at a predetermined point to neutralize the pressure therein, and means in the conduit to engage a load raised above the venting means.

887,726. HUMIDIFYING APPARATUS. William J. Kelley, Central Falls, R. I.

MAY 19.

887,801. ROCK-DRILLING MACHINE. Henry Hellman and Lewis C. Bayles, Johannesburg, Transvaal.

887,884. TRACK-SANDING MECHANISM. Charles P. White, Greensboro, N. C.

887,925. SHOCK-ABSORBER. David M. Davis, Washington, D. C.

5. In a device as set forth, a hollow member elliptical in cross-section comprising three chambers, a central chamber and two auxiliary chambers, a piston movable in the central chamber, said central chamber having air vents intermediate the ends thereof, the auxiliary chambers having communication with the central chamber in such wise that upon the upward stroke of the piston, the air is forced into one of said auxiliary chambers and upon the downward stroke, air is forced into the other auxiliary chamber, at the same time air is returned from the first-named auxiliary chamber in reduced volume upon the downward stroke of the piston while air is returned from the second mentioned auxiliary chamber in reduced volume upon the upward stroke of the piston thereof

887,931. AERIAL APPARATUS. Charles J. A. Fiesse, Washington, D. C.

887,955. COMPRESSOR OR BLOWER. Richard J. McCarty, Kansas City, Mo.

887,974. ART OF SMELTING ORE. Alfred Steinbart, Pittsburg, Pa.

1. As an improvment in the art of smelting ore, the method herein described which consists in lessening the percentage of moisture in the air to be forced into the furnace to a point below that of saturation at atmospheric pressure and at the temperature of a natural cooling medium, maintaining the moisture at a slowly varying percentage below such point of saturation by subjecting the air to comppression and to such natural cooling medium and forcing the air into the furnace.

888,007. STARTING MECHANISM FOR EXPLOSIVE-ENGINES. Harry C. Fricke and George E. Turner, Pittsburg, Pa.

1. In an explosive engine, the combination with the cylinder and piston, and means for supplying an explosive mixture thereto, of means for supplying a compressed motor fluid to said cylinder, a valve chest for said fluid supply, a cam operated by the engine, and a valve in said valve chest normally out of operative relation with said cam, said valve being constructed to be forced into operative relation to the cam by the admission of compressed fluid to said valve chest, substantially as described.

888,074. MEANS FOR STARTING INTERNAL-COMBUSTION ENGINES. Giovanni Enrico, Turin, Italy.

1. In an internal combustion engine, the combination with the cylinder of inlet and outlet valves, cams for operating such valves, a hollow cam shaft carrying such cams, an additional valve adapted to admit comppressed fluid to the engine for starting purposes, a cam for operating said additional valve, said cam being independent of the outlet and inlet valve cams, and being adapted to slide on said cam shaft, and a second shaft for operating the cam for the additional valve, said shaft extending within the cam shaft and being connected to its cam through slots formed in the cam shaft.

888,126 VALVE MECHANISM FOR AIR-COMPRESSORS. Theodore H. Smith, San Francisco, Cal.

888,164. PNEUMATIC DRILL. Martin Hardsocg, Ottumwa, Iowa.

888,189. AUTOMATIC TRAIN-PIPE COUPLING. Nicholas F. Niederlander, St. Louis, Mo.

888,207. FLUID-PRESSURE BRAKE. Walter V. Turner, Edgewood, Pa.

888,239. PNEUMATIC FLUE-EXPANDER. Harry Kelly, Houston, Tex.

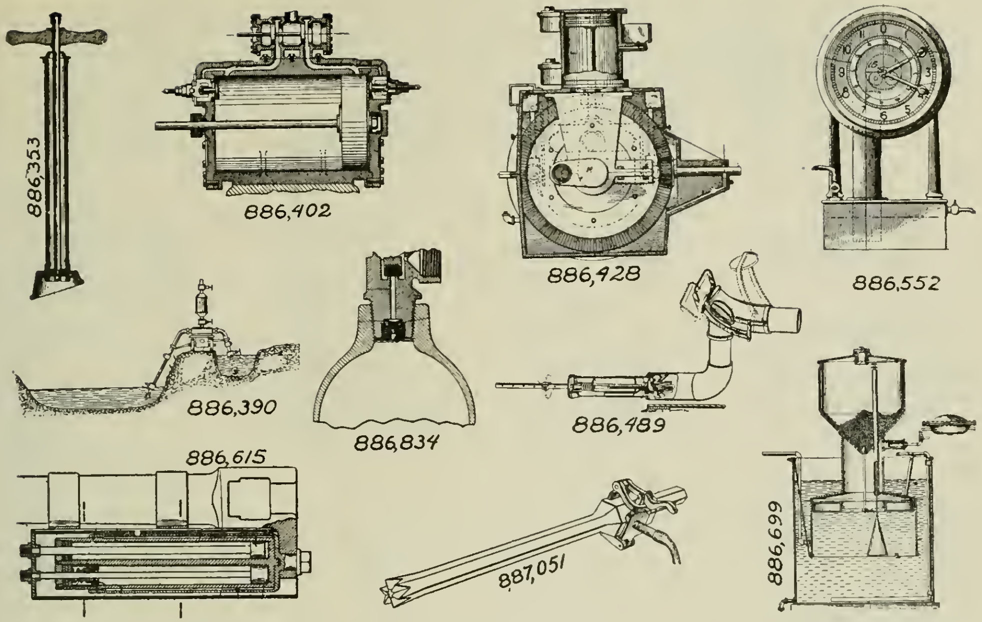
888,267. AIR-SHIP. Julius C. Sandrik, South Bethlehem, Pa.

888,354. APPARATUS FOR ELEVATING GRAIN AND OTHER GRANULAR OR PULVERULENT MATERIALS. Louis G. Rohde and Henri J. Rohde, Paris, France.

888,449. COLOR AND DYE SPRAYER. Hans Mikorey, Schoneberg, near Berlin, Germany

MAY 26.

888,492. ROCK-DRILL. James S. Harlow, Mineral, Va.



PNEUMATIC PATENTS, MAY 5.

888,497. ROCK-DRILLING MACHINE OR ENGINE. Henry Hellman and Lewis C. Bayles, Johannesburg, Transvaal.

888,506. TURBINE-DRIVEN ROCK-DRILL. Moses Kellow, Penrhyndendraeth, England.

888,553. AIR-COMPRESSOR. Charles P. Tolman, New York, N. Y.

888,565. POSITIVE-PRESSURE BLOWER. John W. Wilson, New York, N. Y.

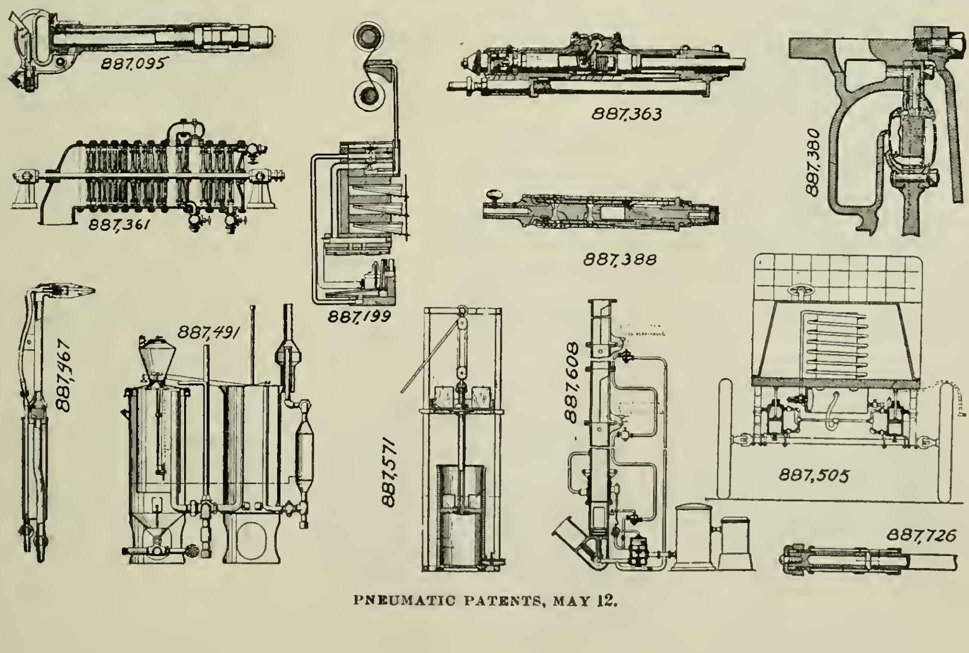
888,567. AIR-BRAKE. John B. Wright, Greensboro, N. C.

888,571. PNEUMATIC STACKER. Lars M. Anderson, Crookston, Minn.

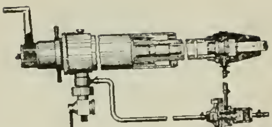
888,762. AIR-PUMP. Samuel E. Spencer, Springville, N. Y.

888,790 METHOD AND APPARATUS FOR CONSTRUCTING SUBAQUEOUS TUNNELS. Benjamin Douglas, Grosse Ile, Mich.

1. The method of constructing subaqueous tunnels, which consists in building the same within an open bottom shield and in advancing said



PNEUMATIC PATENTS, MAY 12.



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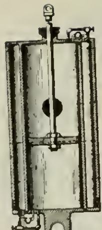

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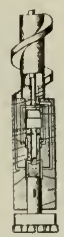

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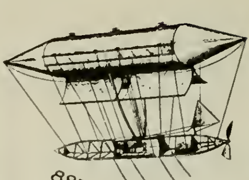

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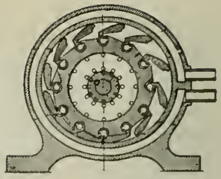

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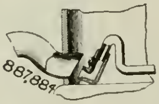

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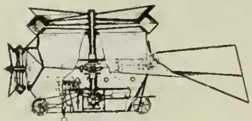

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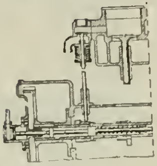

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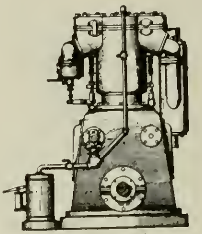

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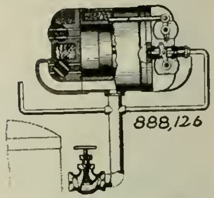

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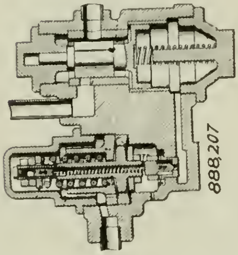

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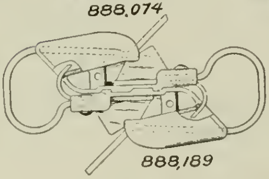

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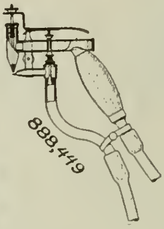

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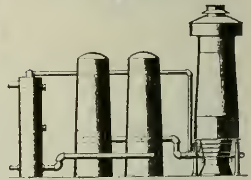

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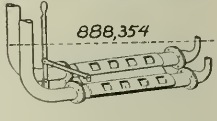

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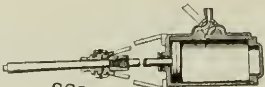


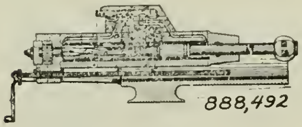
888,239

PNEUMATIC PATENTS, MAY 19.

shield and depressing the water level therein by an unbalanced pneumatic pressure.

888,853. AIR-BRAKE. CHARLES E. SHADE, Tacoma, Wash.

888,914. AIR-VALVE FOR RADIATORS. FRED W. LEUTHESSER, Chicago, Ill.



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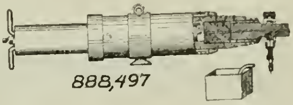

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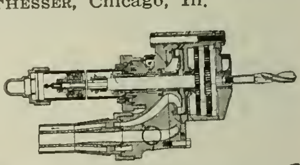

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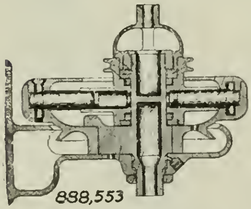

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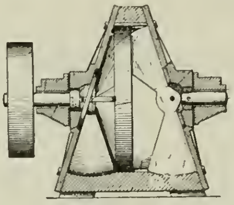

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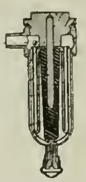

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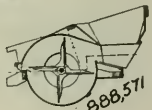

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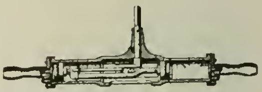

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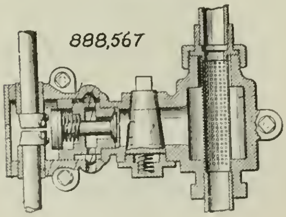

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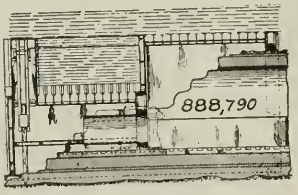

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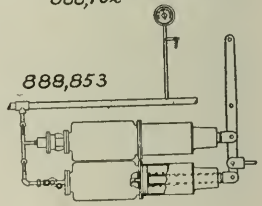

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PNEUMATIC PATENTS, MAY 26.

COMPRESSED AIR
AND EVERYTHING PNEUMATIC.

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THE MOISTURE IN THE ATMOSPHERE

ITS EFFECT ON THE OPERATION OF COMPRESSED AIR MACHINERY, ESPECIALLY AIR BRAKE, MULTIPLE-UNIT TRAIN CONTROL AND TRAIN SIGNAL SYSTEMS.

By H. M.-Prevost Murphy.

Note.—We reprint this valuable paper in full from the *Engineering News* of June 18, 1908, by the kind permission of the writer, Mechanical Engineer Westinghouse Air Brake Company, and of the Engineering News Publishing Company, 220 Broadway, New York, by whom it is copyrighted and now issued in pamphlet form at 25 cents per copy.

Ever since the introduction of compressed air into the railway and commercial fields, much imperfect operation and many failures have resulted from the presence of condensed moisture in vital parts of the apparatus used. Long practical experience and careful, scientific investigation have, however, demonstrated that all difficulties arising from this source may be reduced to comparative insignificance, if not entirely eliminated, by properly installing the various devices concerned. The objects of this article are to point out the physical laws involved in the subject, to explain the most approved methods of securing "dry air" for use in any system, and to establish a correct method for determining the amount of moisture that is deposited by compressed air under various operating conditions.

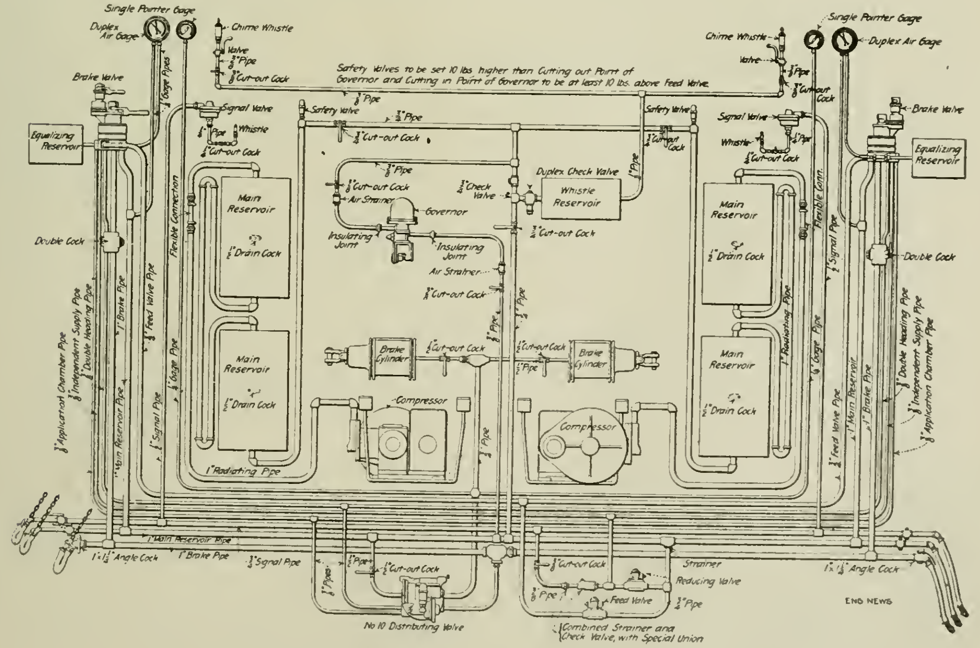

FIG. 1 DIAGRAMMATIC ARRANGEMENT OF A WESTINGHOUSE AIR-BRAKE EQUIPMENT FOR ELECTRIC LOCOMOTIVE.

Although the troubles resulting from "wet air" are of much consequence in stationary work, where complicated pneumatic machines are used, it is seldom that any very serious accidents occur in this field; loss of time and broken tools usually being the extent of the damage done. It is in the operation of modern railways, particularly electric systems, where the problem assumes a most important nature. This will be readily appreciated when it is remembered that on a large number of such roads the block signals, interlocking switches, multiple-unit control equipments and automatic brakes are all operated by compressed air.

Of course, the evil effects of excess moisture, if permitted to enter any of the systems referred to, are readily imagined if indeed not already familiar to the reader. In warm climates, where freezing weather is never experienced, any water passing through and deposited in the various valves and passages is not a positive source of danger, although it may cause extremely sluggish and unsatisfactory operation, but it will inevitably produce a much more rapid deterioration of the apparatus than would otherwise be the case. On the other hand, in latitudes where freezing does occur for even short periods of time, any water which is deposited in these systems is not only liable to burst pipes and valves, but also to so obstruct the ports and passages of the various devices and even to so entirely block the action of the moving parts, that failures from this source are, unfortunately, of too frequent occurrence during the winter months.

In order to clearly understand the situation and to obtain a useful knowledge of the methods employed in practice to obviate the difficulties experienced from the presence of the moisture in the atmosphere, it will be necessary to first investigate the simple unvarying physical laws which govern the case. These laws may be stated as follows:

(1) Atmospheric air always contains some moisture, which it absorbs from rivers, creeks, rainfall, etc.

(2) The amount of moisture present in the atmosphere depends on local conditions and on the weather.

(3) The maximum amount of moisture that pure air can contain depends only on its temperature and pressure, and has an unvarying value for each condition.

(4) The higher the temperature of the air, the greater is the amount of moisture that it can contain.

(5) The higher the pressure of the air, the smaller is the amount of moisture that it can contain.

(6) When air is compressed, its temperature rapidly rises to a high point, which depends on the design and speed of the compressor and the delivery pressure worked against.

(7) The rise of temperature due to the compression of the air, in all cases found in practice, far more than offsets the opposite effect of the rise of pressure on the moisture carrying capacity of the air.

As a result of these laws, it is easy to see how water is deposited by compressed air as it passes from the pump to the various portions of the system. Suppose that a certain amount of atmospheric air enters a compressor and that this air is at the saturation point, that is that it contains all the moisture possible at the existing outside temperature and pressure. Then as this air is compressed as stated in law (7), its moisture carrying capacity very rapidly increases, for the rise of temperature more than offsets the opposite effect of the rise of pressure, consequently all the moisture in the air is still retained by it and passes with it into the main, or storage, reservoir and its connecting pipes. Now if this air is permitted to pass from here into the various parts of the system before being cooled to the outside temperature, it will, of course, carry more moisture with it than it is capable of holding in suspension when the temperature finally drops to the normal point, and this excess quantity will then be deposited, because, the pressure being high, the air cannot hold as much moisture as it did at the same temperature and only atmospheric pressure (law 5).

Now, as will be readily seen, in order to reduce to a minimum the evil effects of this water, which is bound to appear in any compressed air system under average weather conditions, it is most desirable to cause the air to deposit all of its excess moisture in the main reservoirs, from which it may be easily removed by the drain cocks which should always be provided for that purpose. In order to accomplish this completely, it is merely necessary to *cool the air to the outside temperature before it leaves these reservoirs.* This may easily be done by using a sufficiently long air discharge or radiating pipe between the pump and the main reservoirs which should be of large capacity not only to provide for an ample storage of air but also in order to allow the compressed air to remain in them for a length of time sufficient to permit the superfluous moisture to be completely deposited and to insure a liberal supply of cold air at all times. The use of pressure reducing valves between the main reservoirs and the rest of the system is sometimes considered of benefit in securing "dry air," but as such devices simply cause some of the moisture to be deposited in the pipes near at hand (not in the main reservoirs) instead of in the more remote parts of the system, the merits of this method are extremely doubtful and it should never be resorted to unless drain cups are placed in the pipes concerned, for excess water vapor once allowed to pass from the main reservoirs will

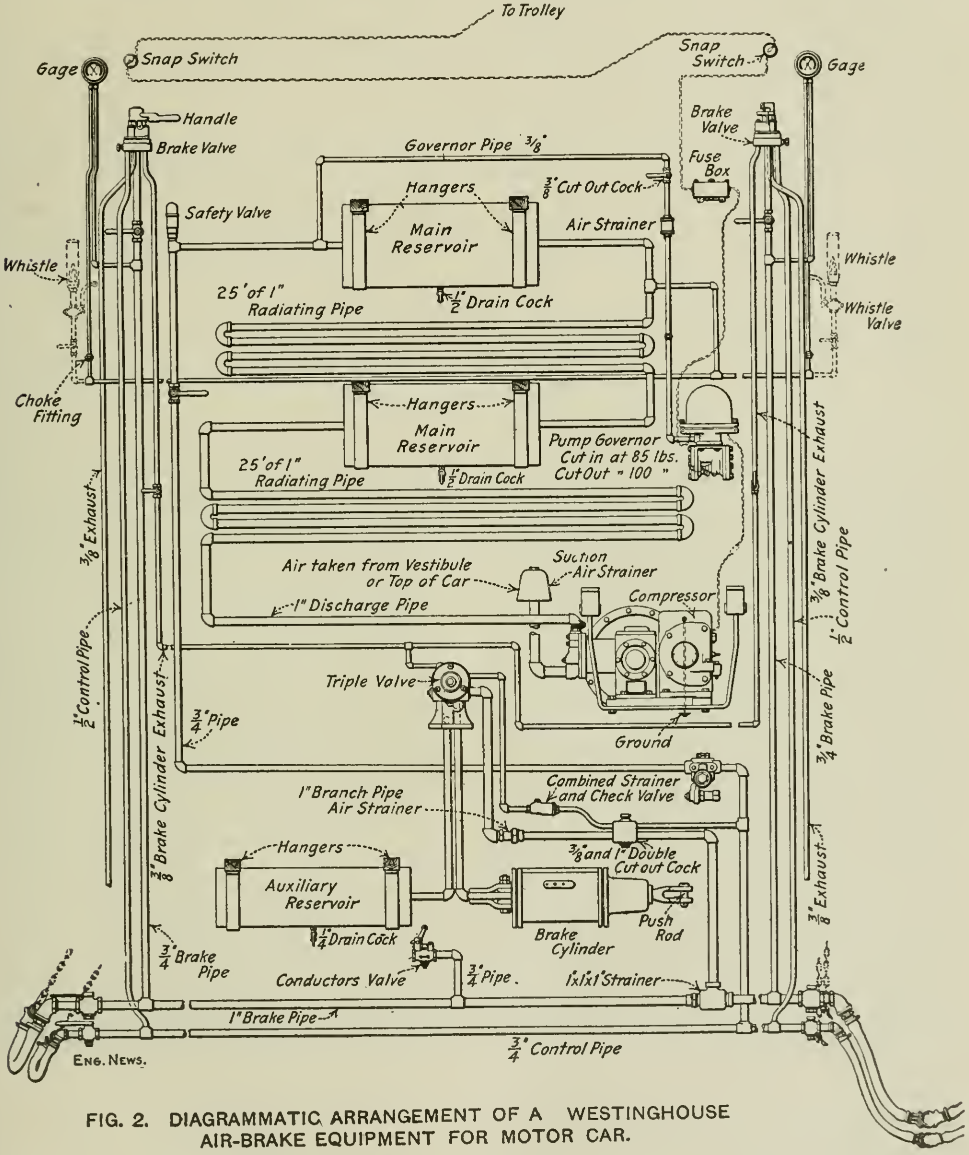

FIG. 2. DIAGRAMMATIC ARRANGEMENT OF A WESTINGHOUSE AIR-BRAKE EQUIPMENT FOR MOTOR CAR.

surely cause ultimate trouble unless it be properly trapped and regularly drained off.

In stationary work where the air is sometimes reheated before being used, in order to increase the efficiency of the devices operated by it, no trouble ought ever to be experienced from the moisture, but in all other installations, including those on railways, long radiating pipes should always be employed. Of course it is true that even if the compressed air be cooled to the existing outside temperature, before leaving the main reservoir, some moisture may be deposited in the rest of the system, if a drop of the outside temperature occurs, but the amount of water thus produced must obviously be very small, and appears merely as little beads on the interior walls of the various devices. It is seldom that any trouble is experienced from this source alone. Moreover, although compressed air may be properly dried before leaving the main reservoirs, some moisture may be temporarily deposited when the air is subsequently expanded to lower pressures, as the moisture carrying capacity of the air is usually affected more by the drop in temperature, resulting from the expansion, than by the drop in pressure, but when the air again attains the outside temperature, the moisture thus deposited will be reabsorbed if it is freely exposed to the compressed air.

In order to show how installations should be made so as to secure "dry air" for use in any system, piping diagrams of modern Westinghouse air-brake equipments for street railway and interurban cars and electric locomotives are illustrated by Figs. 1 and 2, in both of which the radiating pipe is clearly indicated. For stationary plants, such as automatic switch and signal stations, similar radiating systems should be employed, in addition to which water jacketed compressors should be used whenever possible, not only to secure a high mechanical efficiency but also to aid the radiating pipes in the performance of their duty. As a general proposition in railway work, 50 to 70 ft. of this pipe is considered the correct amount, and, when used, no trouble whatever should be experienced with wet air, if the reservoirs are carefully drained every day or, in moist climates, after each long run.

In order to determine exactly what percentage of moisture pure air can contain at various pressures and temperatures, to ascertain how low the "relative humidity" of the atmosphere must be in order that no water will be desposited in any part of a compressed air system, and also to find to what temperature air drawn from a saturated atmosphere must be cooled in order to cause the deposition of moisture to commence, the following discussion is necessary, as no correct method has heretofore been published to cover the situation.

In order to obtain the desired information, is it only necessary to remember a well-known physical law which covers the case of most mixed gases with great exactitude, for water vapor is merely a gas. The law is known as "Dalton's Law of Gaseous Pressures," and may be stated as follows:

"Every portion of a mass of gas enclosed in a vessel contributes to the pressure against the sides of the vessel the same amount that it would have exerted by itself had no other gas been present.

In other words, the total pressure exerted against the interior of a vessel by a given quantity of a mixed gas enclosed in it is the sum of the pressures which each of the component gases would exert separately if it were enclosed alone in a vessel of the same bulk, at the same temperature.

This law applies to mixtures of pure air and saturated water vapor, and in order to determine the maximum weight of moisture that can be held in suspension by one pound of pure air at any temperature and pressure it is merely necessary to proceed as outlined in what follows.

Letting p_2 represent the absolute pressure in lbs. per sq. in., and t the temperature Fahrenheit, the weight in lbs. of 1 cu. ft. of pure air is known to be equal to:

$$2.698192 \times \frac{p_2}{459.2 + t}.$$

Also letting N equal the volume in cubic feet of one pound of pure air at the temperature, t, and pressure, p_2, there results the equation:

$$1 = N \times 2.698192 \times \frac{p_2}{459.2 + t} \quad \text{....(Equation 1)}$$

Now w, the weight in lbs. of 1 cu. ft. of saturated steam (or water vapor) at the temperature, t, and corresponding absolute pressure, p_1, in lbs. per sq. in., has been shown by the author to be accurately expressed, in accordance with the average values given by the most reliable authorities, by the following equation, for all conditions:

$$w = \frac{p_1}{459.2 + t}\left(1.6494 + \frac{0.248\,t}{850 - t}\right)$$

and by letting W represent the weight of N cubic feet of saturated steam at the temperature, t, and pressure, p_1, there results the equation:

$$W = \frac{N p_1}{459.2 + t}\left(1.6494 + \frac{0.248\,t}{850 - t}\right) \ldots\text{(Equation 2)}$$

By taking the N cubic feet of pure air at pressure, p_2, and the N cubic feet of saturated steam at the pressure, p_1, and forcing them both into one vessel of volume, N, keeping the temperature constant at the value, t, the resulting pressure, by Dalton's law, will be $p_2 + p_1$, which may be placed equal to p, thus:

$$p = p_2 + p_1 \ldots\ldots\ldots\ldots\ldots\text{(Equation 3)}$$

W will, of course, represent the maximum weight of water vapor that 1 lb. of pure air can contain under the given conditions of pressure and temperature, as the steam considered is at the saturation point. To obtain the desired formula which will express the value of W in terms of the known quantities it is merely necessary to divide the members of Equation 2 by those of Equation 1, thus:

TABLE 1.—A TABLE WITH FORMULAS GIVING THE WEIGHTS, IN LBS., OF 1 CU. FT. OF DRY AIR, OF 1 CU. FT. OF SATURATED STEAM OR WATER VAPOR AND THE MAXIMUM WEIGHT OF WATER VAPOR THAT 1 LB. OF PURE AIR CAN CARRY AT ANY PRESSURE AND TEMPERATURE. (Copyright, 1908, by H. M.-Prevost Murphy.)

The Values K and H Being Given in the Table for Various Temperatures, t, in Fahrenheit Degrees, the Formulas Are:

$$\text{Weight of 1 Cu. Ft. Saturated Steam} = \frac{1.325271\,K\,H}{459.2 + t}\ \text{(Exactly).}$$

$$\text{Weight of 1 Cu. Ft. Saturated Steam} = \frac{1.3253\,K\,H}{459 + t}\ \text{(Approximately).}$$

H Being Equal to 2.036 × (Gage Pressure + Atmos. Pres., in Lbs. per Sq. Inch).
H, K and t, Having Corresponding Values as Given in Table

$$\text{Weight of 1 Cu. Ft. Pure Dry Air} = \frac{1.325271\,M}{459.2 + t}\ \text{(Exactly).}$$

$$\text{Weight of 1 Cu. Ft. Pure Dry Air} = \frac{1.3253\,M}{459 + t}\ \text{(Approximately).}$$

$$\text{Weight of 1 Cu. Ft. Pure Dry Air} = \frac{2.698192\,P}{459.2 + t}\ \text{(Exactly)}$$

$$\text{Weight of 1 Cu. Ft. Pure Dry Air} = \frac{2.7\,P}{459 + t}\ \text{(Approximately).}$$

M Being the Absolute Pressure Measured in Inches of Mercury.
P Being the Absolute Pressure Measured in Lbs. per Sq. Inch.

Letting W = the Maximum Wt., in Lbs., Water Vapor, that 1 Pound of Pure Air Can Contain, when the Temperature of the Mixture is t, and the Total, or Observed, Absolute Pressure in Lbs. per Sq. Inch Is P, the Value of W, is:

$$W = \frac{K\,H}{2.036\,P - H}\ \text{(Exactly).}$$

The Values of K and H Corresponding to the Existing Temperature Being Given by the Table.

For Any Temperature the Value of K (the Ratio of the Wt. of a Volume of Saturated Stream to an Equal Volume of Pure Dry Air at the Same Temperature and Pressure) May Be Accurately Computed by the Following Formula.

$$K = 0.6113 + \frac{0.092\,t}{850 - t}\ \text{(Exactly).}$$

Note.—The Results Obtained by the Use of Any of the Above Formulas Agree Exactly with the Average Data for Air and Steam Weights as Given by the Most Reliable Authorities and Careful Experiments, for All Pressures and Temperatures, the Value of K Being Correct for All Tamperatures up to the Critical Steam Temperature of 689° F.

TABLE GIVING THE VALUES OF "K" AND "H" CORRESPONDING TO EACH FAHRENHEIT DEGREE OF TEMPERATURE FROM 30° BELOW TO 434° ABOVE ZERO.

Temperature Degrees Fahrenheit	Values of K	Values of H	Temperature Degrees Fahrenheit	Values of K	Values of H	Temperature Degrees Fahrenheit	Values of K	Values of H	Temperature Degrees Fahrenheit	Values of K	Values of H	Temperature Degrees Fahrenheit	Values of K	Values of H
-30	6082	.0099	17	.6132	0941	64	6188	.5962	111	6251	2.654	158	6323	9.177
-29	.6083	.0105	18	6133	.0983	65	6189	.6175	112	.6253	2.731	159	6325	9.400
-28	.6084	.0111	19	.6134	.1028	66	6190	.6393	113	.6255	2.811	160	.6326	9.628
-27	6085	.0117	20	6135	.1074	67	.6192	6617	114	6256	2.892	161	6328	9.860
-26	6086	.0125	21	6136	.1122	68	6193	.6848	115	.6257	2.976	162	6330	10.10
-25	6087	0130	22	.6137	1172	69	6194	7086	116	.6258	3.061	163	6331	10.34
-24	.6088	.0137	23	6139	.1224	70	.6196	.7332	117	6260	3.149	164	6333	10.59
-23	6089	.0144	24	6140	1279	71	6197	7585	118	.6261	3.239	165	6335	10.84
-22	6090	0152	25	.6141	.1336	72	6198	.7846	119	6263	3.331	166	6336	11.10
-21	6091	0160	26	.6142	.1396	73	6199	.8114	120	.6264	3.425	167	6338	11.36
-20	6092	0168	27	6143	1458	74	6201	8391	121	6266	3.522	168	.6340	11.63
-19	6093	.0177	28	6144	1523	75	6202	8676	122	6267	3.621	169	.6341	11.90
-18	6094	.0186	29	6146	.1590	76	6203	.8969	123	6269	3.722	170	6343	12.18
-17	.6095	0196	30	6147	.1661	77	.6205	.9271	124	6270	3.826	171	6345	12.46
-16	6096	.0206	31	.6148	.1734	78	.6206	9585	125	.6272	3.933	172	.6346	12.75
-15	.6097	.0216	32	6149	.1811	79	.6207	9906	126	6273	4.042	173	.6349	13.04
-14	.6098	.0227	33	.6150	1884	80	6209	1.024	127	.6275	4.153	174	.6350	13.34
-13	.6099	0238	34	6151	.1960	81	.6210	1.057	128	6276	4.267	175	.6352	13.65
-12	6100	.0250	35	6153	.2039	82	.6211	1.092	129	.6278	4.384	176	.6353	13.96
-11	.6101	.0262	36	6154	.2120	83	6213	1.128	130	.6279	4.503	177	.6355	14.28
-10	.6102	0273	37	6155	.2203	84	6214	1.165	131	6281	4.625	178	.6357	14.60
- 9	6103	0289	38	.6156	.2292	85	.6215	1.203	132	6282	4.750	179	6359	14.92
- 8	.6104	0303	39	6157	2382	86	.6217	1.242	133	.6284	4.877	180	.6360	15.27
- 7	6105	0317	40	6158	2476	87	.6218	1.282	134	6285	5.008	181	.6362	15.62
- 6	.6107	.0332	41	6160	.2572	88	.6219	1.324	135	6287	5.142	182	.6364	15.97
- 5	6108	0348	42	6161	.2673	89	.6221	1.366	136	.6288	5.280	183	.6365	16.32
- 4	.6109	.0365	43	6162	.2776	90	.6222	1.410	137	6290	5.420	184	.6367	16.68
- 3	6110	0382	44	6163	.2883	91	6223	1.455	138	.6291	5.563	185	.6369	17.05
- 2	.6111	0400	45	6164	.2994	92	6225	1.501	139	.6293	5.709	186	6371	17.43
- 1	6112	0419	46	6166	3109	93	6226	1.548	140	.6294	5.859	187	6373	17.81
0	.6113	.0439	47	.6167	.3227	94	6227	1.597	141	.6296	6.011	188	.6374	18.20
+ 1	.6114	0459	48	.6168	.3350	95	.6229	1.647	142	6298	6.167	189	.6376	18.59
2	.6115	.0481	49	.6169	.3477	96	.6230	1.698	143	6299	6.327	190	.6377	19.00
3	.6116	.0503	50	6170	.3608	97	.6232	1.751	144	.6301	6.490	191	.6380	19.41
4	6117	.0526	51	6172	.3743	98	.6233	1.805	145	.6302	6.656	192	.6381	19.83
5	.6118	.0551	52	6173	.3883	99	6234	1.861	146	6304	6.827	193	.6383	20.25
6	.6120	0576	53	.6174	.4027	100	.6236	1.918	147	.6305	7.001	194	.6385	20.69
7	6121	0603	54	.6175	.4176	101	.6237	1.976	148	.6307	7.178	195	.6387	21.13
8	.6122	.0630	55	6177	.4331	102	.6238	2.036	149	.6309	7.359	196	.6389	21.58
9	.6123	0659	56	.6178	4490	103	.6240	2.098	150	6310	7.545	197	.6391	22.04
10	.6124	.0690	57	6179	.4655	104	.6241	2.161	151	6312	7.736	198	.6393	22.50
11	.6125	.0722	58	6180	.4824	105	.6243	2.226	152	.6313	7.929	199	6394	22.97
12	.6126	.0756	59	6182	.4999	106	.6244	2.294	153	6315	8.127	200	6396	23.46
13	.6127	.0789	60	.6183	.5180	107	6246	2.362	154	.6317	8.328	201	.6397	23.94
14	.6128	.0824	61	.6184	.5367	108	.6247	2.432	155	.6318	8.534	202	.6400	24.44
15	.6130	.0862	62	.6185	.5559	109	.6248	2.504	156	6320	8.744	203	6402	24.95
16	.6131	.0900	63	.6187	.5758	110	.6250	2.578	157	.6322	8.958	204	.6404	25.47

Temperature Degrees Fahrenheit	Values of K	Values of H	Temperature Degrees Fahrenheit	Values of K	Values of H	Temperature Degrees Fahrenheit	Values of K	Values of H	Temperature Degrees Fahrenheit	Values of K	Values of H	Temperature Degrees Fahrenheit	Values of K	Values of H
205	6405	25.99	251	6499	61.89	297	.6607	130.8	343	.6736	250.9	389	6890	444.4
206	6407	26.53	252	6501	62.97	298	6610	132.8	344	.6739	254.2	390	6893	449.6
207	6409	27.07	253	.6503	64.08	299	.6612	134.8	345	.6741	257.6	391	.6897	454.9
208	6411	27.62	254	6505	65.21	300	6615	136.8	346	.6745	261.0	392	6901	460.2
209	.6413	28.18	255	.6508	66.34	301	.6617	138.9	347	.6749	264.5	393	6905	465.6
210	6415	28.75	256	.6510	67.49	302	6620	141.0	348	6751	268.0	394	6908	470.9
211	.6417	29.33	257	.6512	68.66	303	.6623	143.1	349	6754	271.5	395	.6911	476.4
212	6419	29.92	258	.6514	69.85	304	.6625	145.3	350	6757	275.0	396	.6915	481.9
213	6421	30.53	259	.6516	71.05	305	6628	147.4	351	.6760	278.6	397	6919	487.4
214	6423	31.14	260	.6518	72.26	306	6631	149.6	352	.6763	282.2	398	6923	493.0
215	6424	31.76	261	6521	73.50	307	6633	151.8	353	.6767	285.9	399	.6927	498.7
216	6426	32.38	262	.6523	74.75	308	6636	154.1	354	.6770	289.6	400	6931	504.4
217	6428	33.02	263	6525	76.02	309	6639	156.3	355	6773	293.3	401	6935	510.1
218	6430	33.67	264	6528	77.30	310	6641	158.7	356	6776	297.1	402	6939	515.9
219	6432	34.33	265	6530	78.61	311	.6644	161.0	357	.6780	300.9	403	6943	521.7
220	6434	35.01	266	6532	79.93	312	.6647	163.3	358	.6783	304.8	404	6947	527.6
221	6436	35.69	267	6534	81.27	313	.6650	165.7	359	6786	308.7	405	6951	533.5
222	6438	36.38	268	6537	82.62	314	.6652	168.1	360	6789	312.6	406	6955	539.6
223	.6440	37.08	269	6539	84.00	315	.6655	170.5	361	.6792	316.6	407	.6958	545.6
224	6442	37.80	270	6541	85.39	316	.6658	173.0	362	.6795	320.6	408	6962	551.6
225	6444	38.53	271	6543	86.83	317	6661	175.6	363	6799	324.6	409	6966	557.8
226	6446	39.27	272	.6546	88.26	318	.6663	178.0	364	.6803	328.7	410	6970	564.0
227	6448	40.02	273	.6548	89.71	319	6666	180.6	365	6806	332.8	411	6975	570.2
228	6451	40.78	274	.6551	91.18	320	6669	183.1	366	.6809	337.0	412	.6979	576.5
229	6453	41.56	275	.6553	92.67	321	6671	185.7	367	6813	341.2	413	6983	582.8
230	.6455	42.34	276	.6555	94.18	322	6674	188.3	368	6816	345.4	414	6987	589.3
231	6457	43.14	277	.6558	95.71	323	6677	191.0	369	.6820	349.7	415	.6991	595.7
232	6458	43.95	278	6560	97.26	324	6680	193.7	370	6822	354.0	416	6995	602.2
233	.6460	44.77	279	.6563	98.83	325	6683	196.5	371	6825	358.4	417	6999	608.8
234	6463	45.61	280	6565	100.4	326	6686	199.2	372	.6829	362.8	418	.7003	615.4
235	6465	46.46	281	.6568	102.0	327	.6689	202.0	373	.6832	367.3	419	.7007	622.1
236	6467	47.32	282	.6570	103.7	328	.6691	204.8	374	6836	371.8	420	.7012	628.8
237	6469	48.19	283	6572	105.3	329	6694	207.7	375	6839	376.3	421	.7016	635.6
238	6471	49.08	284	6575	107.0	330	.6697	210.5	376	6843	380.9	422	.7021	642.3
239	.6473	49.98	285	6577	108.7	331	.6700	213.5	377	6847	385.5	423	.7025	649.4
240	6475	50.89	286	.6580	110.4	332	.6703	216.4	378	6850	390.2	424	7029	656.3
241	.6477	51.83	287	6582	112.1	333	6707	219.4	379	6853	394.9	425	7033	663.3
242	6479	52.77	288	6584	113.9	334	.6709	222.4	380	6857	399.6	426	7037	670.4
243	6481	53.72	289	6587	115.8	335	6712	225.4	381	.6861	404.3	427	.7042	677.5
244	6484	54.69	290	6590	117.5	336	6715	228.5	382	6865	409.3	428	.7046	684.7
245	6486	55.68	291	6592	119.3	337	6717	231.6	383	6868	414.2	429	7051	691.9
246	6488	56.67	292	6594	121.2	338	6721	234.7	384	6871	419.1	430	7055	699.2
247	6490	57.69	293	6597	123.1	339	6724	237.9	385	.6875	424.1	431	.7059	706.5
248	6492	58.71	294	6600	125.0	340	6727	241.1	386	6879	429.1	432	7064	713.9
249	.6494	59.76	295	6602	126.9	341	6730	244.3	387	6882	434.2	433	.7068	721.6
250	6496	60.81	296	6604	128.8	342	6733	247.6	388	6886	439.3	434	7073	728.9

$$\frac{W}{1}=\frac{\dfrac{N p_1}{459.2+t}\left(1.6494+\dfrac{0.248\,t}{850-t}\right)}{2.698192\,N\dfrac{p_2}{459.2+t}}$$

which may be simplified by division to give,

$$W=\left(0.6113+\frac{0.092\,t}{850-t}\right)\frac{p_1}{p_2}$$

but (by Equation 3) $p_2 = p - p_1$ and by substituting this value of p_2 in the above equation there results:

$$W=\left(0.6113+\frac{0.092\,t}{850-t}\right)\frac{p_1}{p-p_1}\text{ ; or,}$$

$$W=\left(0.6113+\frac{0.092\,t}{850-t}\right)\frac{H}{2.036\,p-H}\text{ (Equation 4)}$$

where H represents the tension of saturated steam (or water vapor) at the temperature, t, in ins. of mercury.

In order to simplify matters, the first member of Equation 4 may be placed equal to K, thus:

$$W=\frac{K\times H}{2.036\,p-H}\ldots\text{(Equation 5)}$$

The values of K and H corresponding to all ordinary temperatures, are given in Table I. That is, Equation 5 is the desired simple formula which gives the maximum weight, W, (in pounds) of water vapor that one pound of pure air can contain when the total or observed absolute pressure in pounds per square inch is p, and the values of K and H correspond to the existing temperature, whatever its value may be. Table I. will also be found of much practical value in other connections by noting that H is simply the absolute pressure of saturated steam expressed in inches of mercury, the absolute pressure in lbs. per square inch being readily found for any desired temperature by dividing the values of H by 2.036; also K represents the ratio of the weight of 1 cu. ft. of saturated steam at any given temperature and corresponding pressure to 1 cu. ft. of pure air at the same pressure and temperature.

It is worthy of note, as demonstrated in the preceding discussion and as proved by numerous experiments, that the ratio just referred to is *not a constant* but has a different value for each temperature, consequently all of the tables heretofore published in text-books and hand-books which give the relative and total weights of air and water vapor and of the mixture, and which have been computed on the erroneous assumption that the ratio in question is a constant, are not to be relied on with any degree of accurracy, as the majority of the values furnished by such tables are far from being correct. Table II. given in this article is figured correctly by the use of the exact ratio for each temperature specified and should prove of much value in all moisture computations—some of its uses are demonstrated by the last two examples of the four which will now be given to illustrate a few of the important practical applications of Equation 5 and Tables I. and II.

SPECIFIC APPLICATIONS OF FORMULAS AND TABLES.

Example 1.—How low must the relative humidity be, when the atmospheric pressure is 14.7 lbs. per sq. in. and the outside temperature is 60°, in order that no moisture may be deposited in any part of a compressed air system carrying a constant gage pressure of 90 lbs. per sq. in.? The relative humidity of the atmosphere is, of course, the percentage of moisture which the air contains at any particular pressure and temperature as compared with the maximum amount which it can hold under the same conditions.

Solution.—In order to solve this problem it is merely necessary to use Equation 5 to determine the maximum amount of moisture trat 1 lb. of pure air can contain at 90 lbs. gage pressure (or 104.7 lbs. absolute pressure) and 60° temperature which may be easily done by aid of Table I., thus:

and to find the maximum weight of moisture

$$W\text{ (at 104.7 lbs.)}=\frac{K\,H}{2.036\,p-H}=$$

$$\frac{0.6183\times0.5180}{2.036\times104.7-0.5180}=.001506\text{ lb.;}$$

but in order that no moisture may be deposited that 1 lb. of air can contain at 60° temperature and 14.7 lbs. absolute pressure, thus,

$$W\text{ (at 14.7)}=\frac{K\,H}{2.036\,p-H}=$$

$$\frac{0.6183\times0.5180}{2.036\times14.7-0.5180}=.01089\text{ lb.;}$$

in the system, each pound of pure air must not contain over .001506 lb. of moisture, and therefore the relative humidity must not be above the following value:

$$\frac{.001506}{.01089} \times 100 = 13.83\% \ldots\text{(Answer)}$$

This example shows that, unless operating in an extremely dry climate, some moisture is sure to be deposited in the system and that this amount depends on the relative humidity of the atmosphere as well as on the outside temperature and the pressure carried in the main reservoirs.

TABLE II.—WEIGHTS, IN LBS., OF PURE DRY AIR, WATER VAPOR AND SATURATED MIXTURES OF AIR AND WATER VAPOR AT VARIOUS TEMPERATURES, UNDER NORMAL ATMOSPHERIC PRESSURE OF 29.921 INS. OF MERCURY OR 14.6963 LBS. PER SQ. IN. ALSO VALUES OF THE ELASTIC FORCE OR PRESSURE OF THE AIR AND VAPOR WHEN PRESENT IN SATURATED MIXTURES. (Copyright, 1908, by H. M.-Prevost Murphy.)

Temperatures in Fahrenheit Degrees.	Weight of One Cubic Foot of Pure Dry Air	Saturated Mixtures of Air and Water Vapor					
		Elastic Force of the Water Vapor or Saturated Steam in Inches of Mercury	Elastic Force of the Air alone, when Saturated with Water Vapor in Ins. of Mercury	Weight of the Water Vapor in One Cu. ft. of the Mixture, or Wt. of One Cu. ft. of Saturated Steam	Weight of the Air in One Cubic Foot of the Mixture	Total Weight of One Cubic Foot of the Mixture	Weight of Water Vapor Mixed with One Pound of Pure Air
0	.086354	.0439	29.877	.000077	.086226	.086303	.000898
12	.084154	.0754	29.846	.000130	.083943	.084073	.001548
22	.082405	.1172	29.804	.000198	.082083	.082281	.002413
32	.080728	.1811	29.740	.000300	.080239	.080539	.003744
42	.079117	.2673	29.654	.000435	.078411	.078846	.005554
52	.077569	.3883	29.533	.000621	.076563	.077184	.008116
62	.076081	.5559	29.365	.000874	.074667	.075541	.011709
72	.074649	.7846	29.136	.001213	.072690	.073903	.016691
82	.073270	1.092	28.829	.001661	.070595	.072256	.023526
92	.071940	1.501	28.420	.002247	.068331	.070578	.032877
102	.070658	2.036	27.885	.002999	.065850	.068849	.045546
112	.069421	2.731	27.190	.003962	.063085	.067047	.062806
122	.068227	3.621	26.300	.005175	.059970	.065145	.086285
132	.067073	4.750	25.171	.006689	.056425	.063114	.118548
142	.065957	6.167	23.754	.008562	.052363	.060925	.163508
152	.064878	7.929	21.992	.010854	.047686	.058540	.227609
162	.063834	10.097	19.824	.013636	.042293	.055929	.322407
172	.062822	12.749	17.172	.016987	.036055	.053042	.471146
182	.061843	15.965	13.956	.021000	.028845	.049845	.728012
192	.060893	19.826	10.095	.025746	.020545	.046291	1.25319
202	.059972	24.442	5.479	.031354	.010982	.042336	2.85507
212	.059079	29.921	0.000	.037922	.000000	.037922	Infinite

Note.—Air is said to be saturated with water vapor when it contains the maximum amount possible at the existing temperature and pressure.

Example 2.—When compressing air into a reservoir carrying a constant gage pressure of 75 lbs., from a saturated atmosphere of 14.7 lbs. absolute pressure and a temperature of 70°, to what temperature must the air be cooled after compression in order to cause the deposition of moisture to commence?

Solution.—To answer this question, first find the maximum weight of moisture contained by 1 lb. of pure air at 14.7 lbs. pressure and 70° temperature, by aid of Table I. and Equation 5, thus:

$$W = \frac{K\,H}{2.036\,p - H} = \frac{0.6196 \times 0.7332}{2.036 \times 14.7 - 0.7332} = 0.01556 \text{ lb.}$$

then the temperature to which the air must be cooled in order to cause the deposition of moisture to begin may readily be found by placing this value of 0.01556 in Equation 5 together with the value of p equal to 75 + 14.7, thus:

$$0.01556 = \frac{K\,H}{2.036 \times 89.7 - H} = \frac{K\,H}{182.63 - H}$$

or $H = \dfrac{2.842}{0.01556 + K}$ and the temperature which satisfies this equation is found by aid of Table I. to be approximately 129° F. (Answer.)

That is, in this case, unless the air be cooled to 129° before being drawn from the main reservoirs none of the moisture contained by it will be deposited in these reservoirs, so that the importance of reducing the temperature of the compressed air to that existing outside is clearly seen, for all of the excess moisture will be deposited while the air in this case is having its temperature reduced from 129° to 70° F.

Example 3.—When the outside temperature is 82° F., and the pressure of the atmosphere is 14.6963 lbs. per sq. in., the relative humidity being 100 per cent., in what time will one gallon of water be deposited in a main reservoir when the air is cooled to 82°, and the gage pressure is 100 lbs. per sq. in., when a compressor is supplying an average of 30 cu. ft. of the moist atmosphere per minute?

Solution.—To solve this problem it is merely necessary to find the difference between the maximum weight of moisture mixed with 1 lb. of pure air at the two pressures concerned, the temperature being 82° in both cases. For the atmospheric pressure of 14.6963 lbs. the desired weight may be computed by Equation 5 and Table I., or may be more easily found by aid of Table II., which gives the desired value in the eighth column as 0.023526 lb. For 10 lbs. gage pressure, the weight may be found by Equation 5 and Table I., thus:

$$W = \frac{K\,H}{2.036\,p - H} = \frac{0.6211 \times 1.092}{2.036 \times 114.6963 - 1.092} = 0.002918 \text{ lb}$$

and therefore the weight of moisture deposited by each pound of pure compressed air is 0.023526 — 0.002918 = 0.020608 lb. Now Table II., column 6, shows that each cu. ft. of the moist atmosphere contains 0.070595 lb. of pure air, therefore the number of cu. ft. that must be delivered to cause 1 lb. of water to be deposited is:

$$\frac{1}{0.070595} \times \frac{1}{0.020608} = 687.37 \text{ cu. ft.}$$

and one gallon of water weighs 8.32 lbs. (approximately) at 82° F., therefore 8.32 × 687.37 = 5,719 cu. ft. of the moist atmosphere must be delivered to cause one gallon of water to be deposited, and the time required with the 30-cu. ft. compressor will be:

$$\frac{5{,}719}{30} = 191 \text{ min. (approx.)} = 3 \text{ hrs., } 11 \text{ min.}$$

(Answer.)

This example shows clearly that a large amount of moisture may be deposited in a very short time, under certain conditions, and thus emphasizes the importance of frequently draining the main reservoirs, which if not properly attended to may not only have their air storage capacity greatly depleted by the presence of the water, but may in time become so full of it that there will be no room left for the deposition of additional moisture and consequently the radiating system will be rendered of no value.

Example 4.—With the same system and under the same conditions as those stated in Example 3, what is the loss in volumetric efficiency of the plant when the excess moisture is properly trapped in the main reservoirs?

Solution.—To solve this problem it is merely necessary to proceed as follows: Table II. shows that, before compression, each pound of pure air is mixed with 0.23526 lb. of water vapor and that the weight of 1 cu. ft. of the mixture is 0.072256 lb., consequently the volume of the 1 lb. of air and 0.023526 lb. of vapor is

$$\frac{1.023526}{0.072256} = 14.165 \text{ cu. ft.}$$

Now for 100 lbs. gage pressure and 82° temperature, it was shown in Example 3 that 1 lb. of pure air can hold only 0.002918 lb. of water vapor in suspension. each pound of air having deposited 0.020608 lb. of water in the main reservoir. Also Table II. shows that the weight of 1 cu. ft. of pure water vapor at 82°, and at the corresponding tension of 1.092 ins. of mercury, is 0.001661 lb., consequently by Dalton's law the volume of the mixture consisting of 1 lb. of pure air and 0.002918 lb. of saturated water vapor (or steam), at 100 lbs. gage pressure is the same as that of the saturated steam alone under the conditions just mentioned, that is, the volume of the mixture is:

$$\frac{0.002918}{0.001661} = 1.757 \text{ cu. ft.}$$

(This value may easily be checked by finding the pressure in inches of mercury of the 1 lb. of pure air when compressed into this volume, which when added to 1.092 will give the total pressure of the mixture, namely, the absolute pressure in inches of mercury corresponding to 100 lbs. gage pressure.)

Finally (by Marriotte's or Boyle's law), the volume of these 1.757 cu. ft. of mixed gas at 114.6963 lbs. absolute pressure when expanded to atmospheric pressure will be,

$$\frac{114.6963}{14.6963} \times 1.757 = 13.712 \text{ cu. ft.};$$

consequently the decrease of volume, that is, the loss of volumetric efficiency is,

$$14.165 - 13.712 = 0.453 \text{ cu. ft., or } \frac{0.453}{14.165} \times 100$$

$$= 3.2\%. \text{ (Answer.)}$$

This example shows clearly that, particularly in warm, moist climates, there is a very appreciable loss in the efficiency of compressors, due to the condensation of water vapor. Of course this loss is unavoidable in railway work, and is far preferable to allowing the moisture to pass into the working parts of the system, but in stationary work where reheaters are used, this cause of decreased efficiency may be obviated, and this problem should be of particular interest in this connection, as losses due to this cause have not been carefully considered heretofore and yet may clearly play a very important part in the economical operation of compressed air plants.

THE DEHYDRATION OF AIR

By Joseph H. Hart.

The problem of the dehydration of the ordinary atmosphere for its more efficient utilization in commercial or engineering developments is not one that has appealed, as yet, to the average engineer nor one with which he is at all familiar. The small proportion of water vapor present in the air, although with its deleterious effect in many industries still recognized, has generally been considered of too small account for active consideration in regard to its removal. To-day, however, it is generally recognized that it can be efficiently removed by a number of different processes, which is a distinct step in advance in many industries, and has increased the efficiency of their processes enormously.

In order to realize the extent to which this development has progressed and its possibilities in future installations, we will cite the case of blast-furnace operation for the manufacture of iron. The application of dry-air blast obtained by means of refrigerating machinery has been successfully and economically employed in the Pittsburg district. Isabella furnace at Etna, Pa., produced 350 tons of iron with 2,147 pounds of coke per ton of output, and consumed approximately 40,000 cubic feet of air per minute. The refrigerating plant installed consisted of two ammonia compressors of a nominal capacity of 225 tons of ice-melting effect each. One only of these compressors is generally operated, and the other is held in reserve to help out on especially humid days. The air was cooled from 80 degrees to about 28 degrees F., and the moisture content was lowered from 5.66 grains per cubic foot, as existing in a special test, to 1.75 grains. The air handled after the blowing engines were slowed down, on account of increased density and removal of the moisture, was 34,000 cubic feet per minute. About ten tons of water was collected from the air per day, and the output was increased to 450 tons of iron, with a coke consumption of 1,729 pounds per ton of output. The blowers were slowed down from 114 to 96 revolutions per minute, the air was reduced in amount as stated, and the indicated horse-power of the blowers from 2,700 to 2,013; thus showing a saving of 687 horse-power in operating the blowing engine. As the refrigerating machinery would only require about 530 horse-power when operated at its maximum capacity, the saving in this factor alone was considerable. In addition, the quality of the iron is improved and can be made very constant in character. The ore and fuel were of uniform condition formerly, but the humidity of the air was very variable. It may vary in one day from 20 per cent. to 100 relative humidity, and this may mean a variation of 300 per cent. total in the complete water content for each grain of water vapour present per cubic foot of air. The moisture content which passed through the furnace was approximately 40 gallons of water per hour, and at times this was increased to over 300 gallons.

This synopsis of exact conditions as existing in one special development will show the great importance and possible efficiency of the process in many other applications. The fact that the air is cooled from 80 degrees F to 28 degrees F. during this process, and that this remarkable efficiency can be shown, is a matter for much further surprise and speculation.

Dehydrated air is absolutely necessary in the cotton industry, in tobacco warehouses and in tobacco manufacture in general, in very many of the great storage developments, and, as is shown above, its practical application in the metallurigcal industries results in a remarkable increase in efficiency. Further, to-day air is used for producing cold water by the absorption of vapour from water immediately in contact with it, with the consequent cooling of the water due to the absorption of the latent heat of evaporization required for this operation. Cooling towers, so called, are extremely common in many refrigeration installations, since cold water is absolutely necessary for the operation of the condenser. In fact, wherever condensers operate, if of the open-type variety, they are much increased in efficiency by satisfactory dehydration of the air and the consequent further cooling of the water. A remarkable condition holds in regard to this special development, namely, that warm, dry air has a much greater cooling effect, due to its absorptive power, than cold, moist air used under similar conditions.

The moisture content of the air is a very variable quantity. It varies with locality and with its contiguity to a large body of water. Temperature variations affect its value very greatly, and it is very variable with weather conditions generally. The relative humidity is defined as the ratio of the quantity of moisture that the air holds per given unit at a given temperature to the quantity that it could hold at that temperature without condensation. The water content of atmospheric air will vary 300 per cent. between limitations as represented by February and June conditions without much variation in relative humidity.

This moisture can be removed by any of a large number of chemical agents known as dehydrating compounds. Sulphuric acid and calcium chloride are the chief and most active of these, and formerly air was dried very satisfactorily by being blown through drums filled with calcium chloride or allowed to bubble through tanks containing sulphuric acid. For some reason or other, probably on account of the difficulty of handling the chemical, if calcium chloride, and the deteriorating effect of sulphuric acid on the retaining vessel and the machinery in general, this development has not been general in its utilization. In special applications, such as physical and chemical laboratories, where dry air is often a necessity, in the production of liquid air as a commercial process, and in a number of other minor developments, these processes have been developed and are fairly efficient.

Undoubtedly the special development in the blast furnace, where dehydration is accomplished through refrigeration, owes a very great degree of its efficiency to the increased density of the air, as well as to the removal of the moisture content. Air kept at constant pressure and cooled decreases in density in direct proportion to its absolute temperature fall, and it can be readily assumed that this development in iron-furnace operation will be much extended, with further increase in efficiency, if further cooling can be accomplished without undue loss in the efficiency of that process. In this development it is undoubtedly the cumulative effect of these two effects which results in the remarkable increase in efficiency as shown.

Air, as a general dehydrating agent, will not come into general use in every development, since it possesses a strong competitor in the utilization of superheated exhaust steam for the performance of this duty. Many woolen and textile mills dry their fabric by this application, with very satisfactory results. It is more efficient and more readily available than dry air, on account of its higher temperature and large water absorptive power, since the total moisture content increases rapidly with rise in temperature, and the tendency of all such materials is to become saturated on contact with water.

While undoubtedly blast furnaces could probably remove the water content of the air by means of any of the dehydrating agents, and do it even more efficiently, when the cost of refrigerating machinery is considered, this application is by no means limited in its further development. A number of continuous dehydrating machines utilizing sulphuric acid or calcium chloride have been developed to-day, notably that used in the production of ice by means of the vacuum process, whereby water is made to freeze itself by the rapid evaporation in a vacuum from its surface, with the further absorption by sulphuric acid of the vapour as fast as produced. In this plant the sulphuric acid is carried in a closed cycle continuously in a very efficient process, and the further application of this development for the removal of the moisture from the blast in iron-furnace operation would be very efficient and could be accomplished with minimum first cost in installation of plant. The real application of mechanical refrigeration in this development is undoubtedly the compression of the air with increased efficiency through the increase in density both on account of the removal of water vapour and on account of lowering of initial temperature of compression. Again, the compression itself is accomplished much more effectively with high air density and low initial temperature, since, if accomplished adiabatically, the final exhaust temperature is much diminished, and the mean operating pressure diminished with a further partial elimination of the more inefficient portion of the stroke. That this development will extend to the preparation of air for compression before its production by means of the air compressor is a foregone conclusion, and the efficiency of the process can scarcely be conjectured, since many of the data for such calculation are not at hand. However, it must be born in mind that this problem—namely, that of variation of density and temperature of air—is always present with dehydration, however accomplished. The extent to which the moisture present is objectionable can be readily seen from the foregone example, and undoubtedly many future possibilities are offered for this development. In all vacuum stills where the distillation is accomplished at temperatures lower than those existing under normal atmospheric pressure, this development presents possibilities. In sugar refineries, where the syrup is boiled down at diminished temperature by a maintenance of a vacuum; in condensed milk factories, in oil refineries, and, in fact, wherever distillation occurs under these abnormal conditions, the same result—that of dehydration of this material—can be accomplished readily by blowing dehydrated air through the mixture. Of course, sulphuric acid can be substituted for the absorption of the moisture whenever practicable; but under the example cited its ultimate removal is almost impossible, and it often has a very injurious effect on the finished product.

In a general way, it can be stated that the problem of air dehydration possesses manifold applications. The utilization of refrigeration for the actual dehydration in a number of specific developments will have the sole result ultimately of bringing this problem to the attention of the average engineer, since in all probability the results obtained, while accomplished with remarkable efficiency by mechanical refrigeration, can undoubtedly be successfully attained by much more efficient processes of dehydration.—*Condensed from Cassier's.*

EFFECT OF AIR IN THE CLARIFICATION OF CANE SUGAR

Throughout the substance of the sugar cane there exists quite a large amount of air and other gases, produced in part by the activities of the plant and in part introduced through insect punctures and other injuries. Also, when a normal feed of cane passes between the mill rolls there is entangled a vast quantity of air intimately mixed with the fibre when the bagasse expands like a squeezed sponge as it is relieved from the pressure. Even when maceration water is plentifully used upon this half-dry bagasse, and applied as quickly as possible, not nearly all this air is driven out, as can be plainly shown by squeezing a handful of it under water.

Now, when this partly air-filled, wet bagasse reaches another mill the air and liquid are together subjected to the enormous pressure of the hydraulics (a pressure often still greater with a rigid mill) with the result that a very large part of the air is actually dissolved in the juice by the pressure, precisely as soda water is charged with gas; and juice being more viscous it requires a much longer time for the air to escape on standing than for the gas to separate from carbonated water.

Before an accurate spindle reading can be made, mill juice must stand for some time for the froth to rise, but if, after all this froth has separated, a portion of the underlying and foam-free juice is drawn into a narrow test tube and the air above it is exhausted by suction or otherwise, the reduced pressure will immediately cause to escape to the surface a second cloud of minute air bubbles; and if heat is then applied while a slight vacuum is still maintained, all the remaining air is removed.

Cane juice as it comes from the mill always contains a large amount of air both as air bubbles (froth) and in actual solution; and the length of time between the escape of the juice from the mill and its entry to the juice heater, clarifier, or other defecating apparatus is too short to allow any measurable amount of this entrapped gas to escape. This slowly escaping air is the sole cause of the "capa" or blanket that forms on the surface of the open clarifier, and would otherwise be precipitated to the bottom as a heavy mud.

Each minute bubble of air attaches itself as it forms to a particle of scum, and these bubbles, expanding as the heat increases, bring the impurities to the top with them. Many houses using heaters and high temperatures for the juices with open vessels for settling, are sometimes compelled to boil the juice in these vessels to eliminate the air and secure a separation of the impurities. If the air and gases should be quickly and completely removed between the heater and the open settling vessels the quality and effectiveness of the defecation would be greatly improved.

If passed through a juice heater the immediate effect of higher temperature is to release a large part of the air, but if kept under any considerable pressure all of it cannot escape, or only slowly; and in the modern closed defecation under pressure this slow release of gases subsequent to passage through a superheater causes trouble, for, in a pressure separator, the evolution of gas takes place throughout the whole body of the liquor and the rising bubbles interfere by their upward motion with the downward travel of the scum or cachaza, and slow the subsiding process seriously; also, at the bottom of any tank used for seperation of the mud, the air will be trapped, collecting in large bulk until some momentary disturbance will cause it to break loose and carry with it masses of solid impurities into the separated juice.

One is led to the conclusion that removal of the air must be effected by some form of apparatus which will expose the hot air-charged juice to reduced pressure in an expansion chamber and at the same time spray it in a manner to insure immediate separation of the gases.

This should be done in an apparatus virtually consisting of a shell of wrought iron receiving the hot juice within it through a perforated pipe or sprayer, combined with a surface condenser enclosed in the expansion chamber, formed of tubes through which cold juice circulates on its way to the heater, and the expansion chamber having connections with a vacuum condenser for taking away the air and gases.

The water from condensation of the steam can be readily trapped off, representing so much evaporation, and after passing through such an apparatus the juice, entirely air-free, will deposit its impurities quickly and completely if the liming has been properly attended to.—*Louisiana Planter.*

PRACTICAL PNEUMATIC MILKING

As we have to do with everything pneumatic it comes entirely within our province to describe the interesting apparatus shown in the accompanying half-tone. Instead of being a compressed air apparatus this is operated by vacuum, produced and maintained by a small air pump which may be driven by an electric motor or otherwise, as most convenient.

The system of milking embodied in this apparatus is far and entirely beyond the experimental stage and is in established and extensive use, giving complete satisfaction wherever installed, besides showing substantial savings in the ultimate cost of operations.

The partial vacuum used with the milking machines is about one-half atmosphere. The pump used is of the vertical, single-acting type, placed in any convenient location, and a line of 1¼ or 1½-inch pipe is led along by the stalls, with branches suitably located for connecting between each pair. A vacuum reservoir tank, a safety valve and two vacuum gages are included in the installation.

The milking machine, as it may be called, consists of a strong, heavily tinned, steel pail Fig. 1, weighing about 12 pounds and holding about 55 pounds of milk. The pail is smaller at the top than at the bottom, with a metal cover fitting loosely, but resting on a soft rubber gasket which makes an air-tight joint. A nipple projecting from the cover connects the pail through a suitable hose with a branch cock in the piping system. The cover contains an automatic pulsating mechanism, and attached to it are two lever handle cocks, each of which is connected by a rubber tube 3½ feet long to a small metal connection with four outlets, from each of which a short rubber tube leads to a teat cup provided with a rubber mouthpiece to fit around the base of the teat. When these are slipped on over the teats they are held in place by the suction until removed by the operator. These teat cups, with their rubber mouthpieces, are made in several different sizes to fit different sized teats, and the chief skill or judgment required of the operator is choosing the proper sizes. The pulsator, mounted on the cover, imitates the sucking of the calf, the teat cups first connecting with the vacuum maintained in the pail, thus drawing the milk from the teat; and next breaking the vacuum and allowing a fresh flow of milk into the teat. The vacuum is again created in the cups, an additional portion of milk goes into the pail, and so on continually, until the milk is all drawn.

Each milk pail is connected to the vacuum mains and also to two cows, as shown in Fig. 2. The milk pail, as was said, holds about five gallons, is air tight and *the milk is not exposed to the air* until it goes to the strainers. An operator usually attends to four cows at a time, and the work is done in about the same time that the hand operation would require for one cow, this time varying of course as the cow milks hard or easy. The cows do not seem to be in any way injuriously affected by the use of the machine; in fact it is said that after a cow has been milked by the machine for a few weeks she will most strenuously resent the hand process.

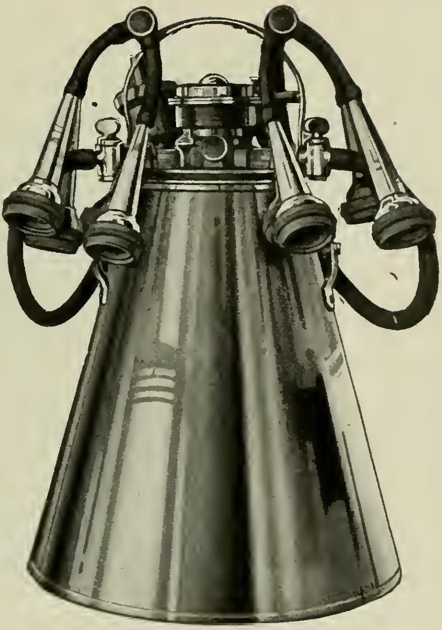
FIG. I. VACUUM MILKING APPARATUS.

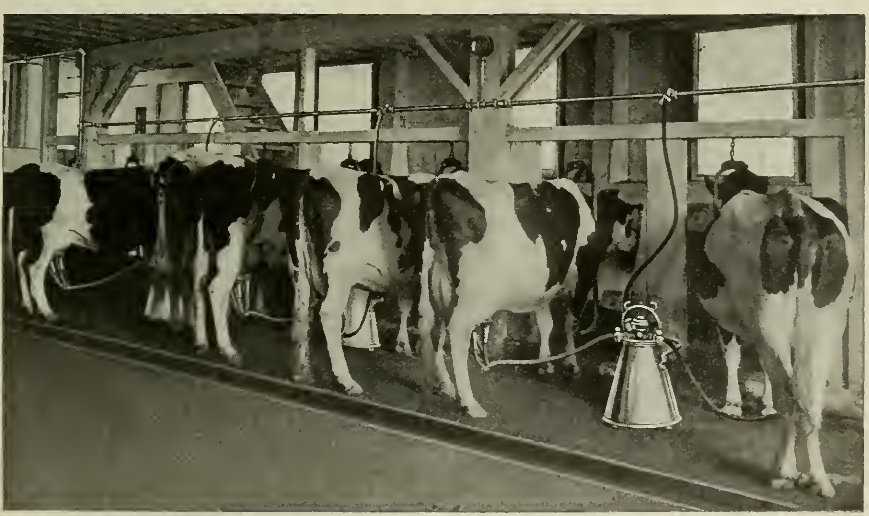
FIG. II. COW-MILKING MACHINES IN USE IN A NEW YORK STATE DAIRY.

The man in charge cleans off the cow's teats and after attaching the milk pail to the main the cups are slipped over the teats and the milking begins. Passing from cow to cow he thus starts the apparatus at work, and then simply keeps watch to see when the milk stops flowing, which is shown in a glass tube on the milk line, when he removes the cups and goes to another cow. Sometimes during the fly season the cow will dislodge the cups, in which case the man in charge has to replace them. This is about all he has to do in the matter, so far as the milking is concerned.

Fig. 2 is from an installation in the New York dairy region showing the milkers in operation. The second and third cows from the right in this picture have been machine milked for over five years. The second one is now giving a little over 50 pounds of milk per day.

These milkers with all appurtenances are built by D. H. Burrell & Co., Little Falls, N. Y. A typical outfit for a certain dairy cost the user all installed, but without the electric motor, less than $275. The cost of operating it, with current at 6 cents per kilowatt-hour, is about $6 a month, and the plant will take the place of two men on a dairy farm caring for 30 to 50 cows.

JOINTS AND FITTINGS FOR HIGH PRESSURE AIR

By H. V. Haight.*

In a pneumatic haulage plant where air pressures of 700 to 1,200 pounds per square inch are employed the detail work of the design is largely a problem of joints, valves and pipe fittings. Only ordinary care and good judgment are needed in the design of these details; it is the common experience in coal mines that with a pneumatic haulage system which has been carefully designed, constructed and erected, there is actually less trouble from leakage with air at 1,000 pounds pressure than with ordinary systems using air at 100 pounds pressure. A plant consisting of an air compressor, an extensive system of piping with valves and fittings, and several locomotives can be made practically bottle tight with air at 1,000 pounds pressure without undue trouble or expense. This being the case, it would appear that with reasonable care a compressed-air system for 100 pounds pressure also can be made practically bottle tight.

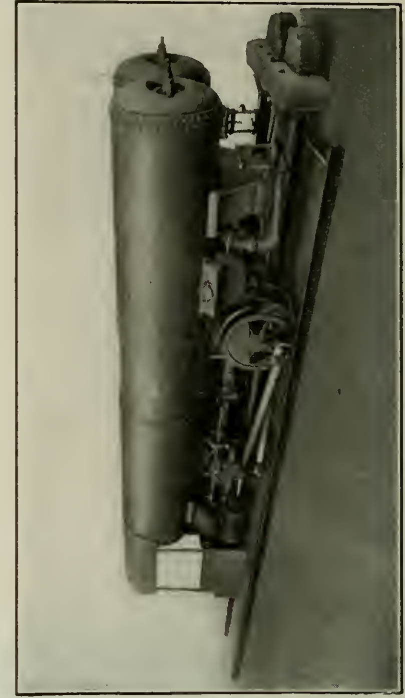

FIG. II. A PNEUMATIC LOCOMOTIVE STORING AIR AT 800 POUNDS PRESSURE.

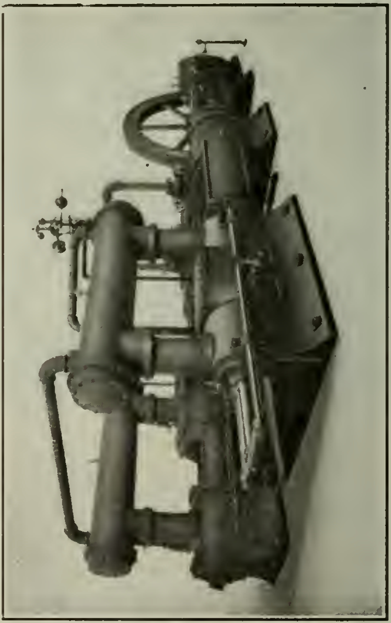

FIG. I. A FOUR-STAGE AIR COMPRESSOR—TERMINAL PRESSURE 1000 POUNDS.

It is hoped that a description of fittings which have been successfully used for high-

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*Chief Engineer, Canadian Rand Company.

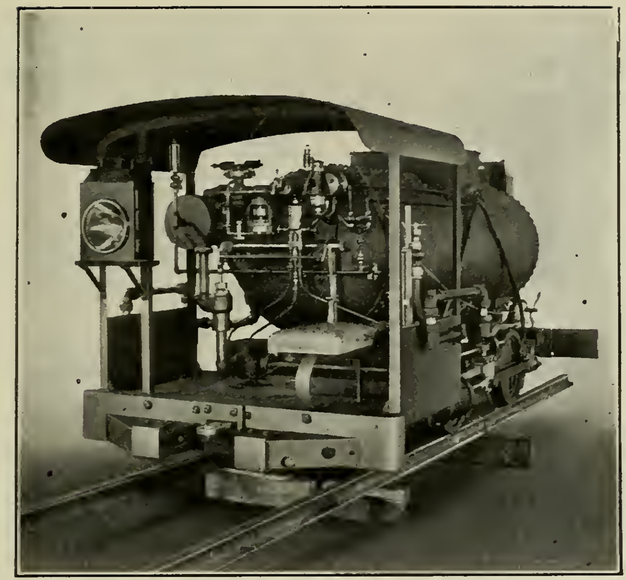


FIG. III. ENGINEER'S END SINGLE TANK LOCOMOTIVE.

pressure air will be of assistance to those who wish to improve existing piping systems, or to install new systems; whether for ordinary or for high air pressures.

The fittings which I purpose to describe are most of them used in connection with Rand Company for coal mines in western Canada. A pneumatic haulage plant consists essentially of an air compressor, a pipe line, used for both storage and distribution, and one or more locomotives.

THE COMPRESSOR PLANT.

For coal mines this usually consists of a duplex steam-driven compressor with its boil-

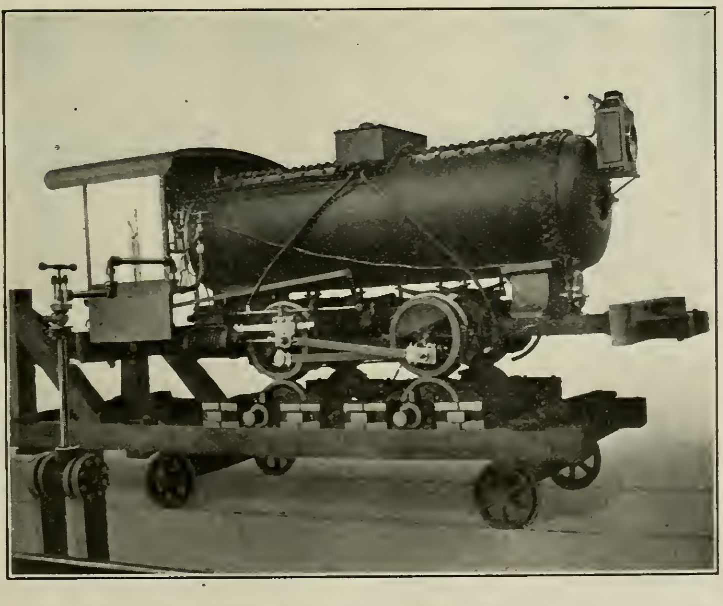


FIG. IV. SIDE VIEW OF LOCOMOTIVE UNDER TEST.

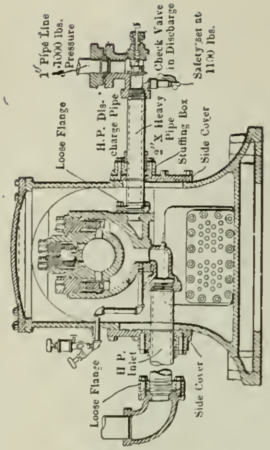


FIG. 6

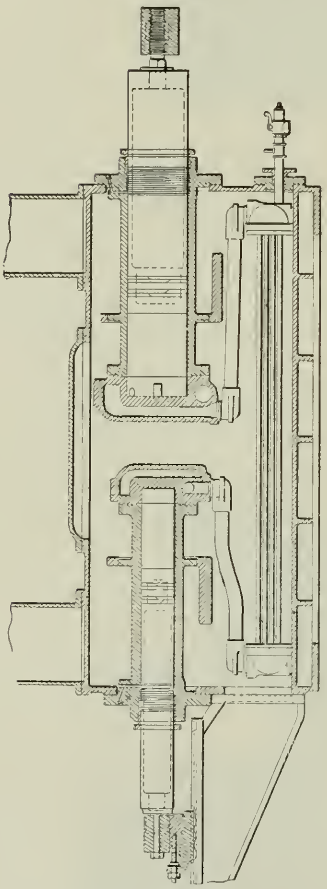


FIG. 5

TANKS CONTAINING THIRD- AND FOURTH-STAGE CYLINDERS

ers and auxiliaries. The air end is four-stage; the terminal pressure is about 1,000 pounds per square inch and the intermediate pressures are about 25, 100 and 375 pounds, respectively. The steam cylinders have usually balanced Meyer valves; although the Pacific Coal Company, near Banff, has a compressor with compound Corliss steam cylinders. Fig. I shows a compressor having duplex Meyer steam cylinders and four-stage air cylinders.

THE PIPE LINE.

The compressed air is delivered into the pipe line which serves both for storage and for distribution. Pipe is cheaper than tanks, even if it is used only for storage, and when large pipe can be used for both storage and distribution it is evidently very much cheaper than separate storage tanks and small distributing pipe. At suitable places along the pipe line are located charging stations for filling the tanks on the locomotives. When the tank is connected to the pipe line and the valve is opened the pressure is equalized at about 800 pounds. With 1,000 pounds pressure in the storage line, 150 pounds pressure remaining in the locomotive tanks and with a capacity ratio of pipe line to tank of 4 to 1 the pressure should equalize at 830 pounds.

THE LOCOMOTIVES.

Pneumatic locomotives are shown in Figs. 2, 3 and 4. The locomotive carries either one or two high-pressure tanks in which air is stored at 800 pounds pressure. From the storage tanks it passes through a series of stop and reducing valves to the auxiliary reservoir where the pressure is maintained at about 150 pounds. Thence the air is admitted by the throttle to the cylinders.

COMPRESSOR JOINTS.

The high-pressure fittings and joints of the air compressor are nearly all used in connection with the tank containing the three and four-stage cylinders. A longitudinal section of this tank is shown in Fig. 5. This shows one of the first machines built; on later machines the pipes connecting the intercooler to the heads have been placed outside the tank for convenience of access. Fig. 6 shows a cross section of the tank on one of the later machines. Referring first to the plunger packing, Fig. 5 shows plungers packed with both piston rings and stuffing boxes; on the later machines the piston rings were omitted as unnecessary. A section of the fourth-stage stuffing box and details of the packing ring and oiler ring, or "lantern," are shown in Figs. 7 and 8.

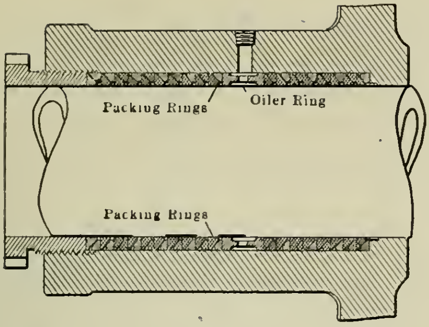
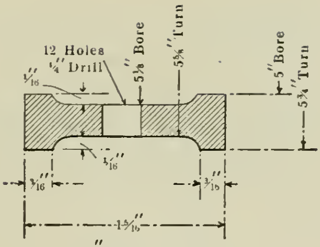
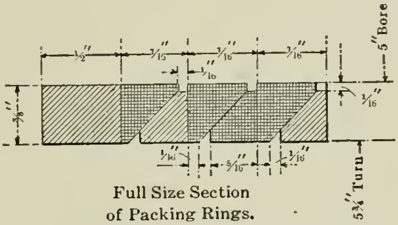


FIG. VII. FIVE-INCH PLUNGER PACKING.



1 - 5½" Oiler Ring, Red Brass



Full Size Section of Packing Rings.

Note:- Every Alternate Ring on Outside of Red Brass

17 - 5 Inside Rings } 2 lbs. Genuine Bbt.
8 - 5 Outside Rings } 1 lb. Lead
9 - 5 Outside Rings - Red Brass

FIG. VIII. DETAILS OF OILER AND PACKING RINGS.

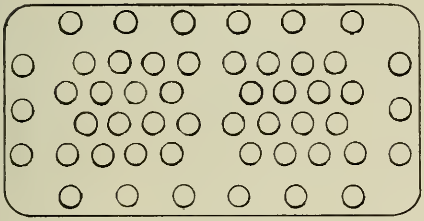


FIG. IX. REVISED LAYOUT OF STUD HOLES IN A TUBE PLATE.

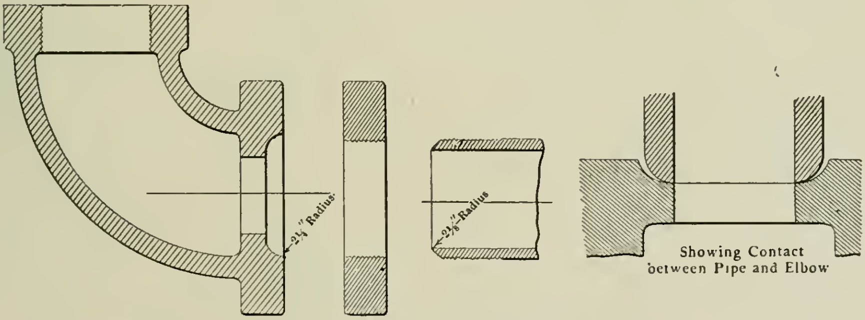


FIG. X. DETAILS OF AN ELBOW AND COMPANION FLANGE OF A BALL AND SOCKET JOINT

It will be seen that the inner rings are all of soft babbitt (two pounds of genuine babbitt to one pound of lead) while half of the outer rings are of babbitt and the rest of red brass. If the outer rings were all of babbitt they would wedge against the outer wall so tightly that it would be very difficult to remove the packing. On the first machine the plungers were simply turned smooth, but the erecting engineer reported that the packing wore away quite rapidly until the plungers had begun to wear smooth. On later machines the plungers were ground and gave no trouble. This packing has given excellent results on large plungers. The position of the oiler ring may perhaps be criticized and it would probably be better to place it nearer the stuffer. Plastic packing was also tried with these plungers. Three grades of commercial plastic packing, each consisting of grains of soft alloy packed in "sausages," were tried on a small machine with a 2⅜-inch plunger. Two of the packings would not hold a pressure of 800 pounds; the third kind proved satisfactory on small plungers. This space for packing was the same as for metallic rings; namely, ⅜-inch all around the plunger.

This same kind of plastic packing was afterward used on large five-inch and nine-inch plungers, but the space for the packing was made ¾ inch. In this case it did not give altogether satisfactory results; there was liable to be a little more packing on one side of the plunger than on the other, and the stuffer could not be screwed up hard enough to pack it all around. The use of a few rings of soft packing in conjunction with the plastic metallic packing might distribute the pressure evenly and overcome the difficulty; or, it may be, if only ⅜ or ½-inch space were allowed for the packing the stuffer could be screwed up tight enough to distribute the packing equally around the plunger. On the whole, however, babbitt rings have been more satisfactory for large plungers.

The intercooler shown below the cylinders carries a working pressure of 375 pounds per square inch. It consists of copper tubes ¾ inch outside diameter and about 1-16 inch thick, expanded into steel-tube plates ⅞ inch thick. These tube plates are secured by studs to headers. Referring to the cross section, Fig. 6, it will be seen that at each corner of the plate there is a stud which comes almost exactly in the corner. Professor Sweet's rule in regard to placing studs on a rectangular plate such as this is: "The studs should not be placed right in the corners." As a matter of fact, with the arrangement shown the corners bent down, causing leakage. The layout of studs was changed to that shown in detail, Fig. 9, which gave no farther trouble. The gasket between the tube plate and header is made of copper wire about 3-16 inch in diameter. A good grade of sheet packing might, however, serve the purpose all right.

A rather peculiar difficulty was experienced with the tubes of one of these intercoolers. In this case the tubes were made of brass, and although they stood the water test at the shops all right, it was reported when the machine was started that some of them were cracked. The matter was taken up with the manufacturers of the tubes, and their explanation was that the tubes were not annealed, that we did not specify annealed tubes, or state what they were to be used for, and that they had sent us unannealed tubes. They stated that these were liable to crack in transit, or even in the store-room. We could not imagine any purpose for which such tubes would be suitable, and concluded that in future it would be safest to use copper tubes.

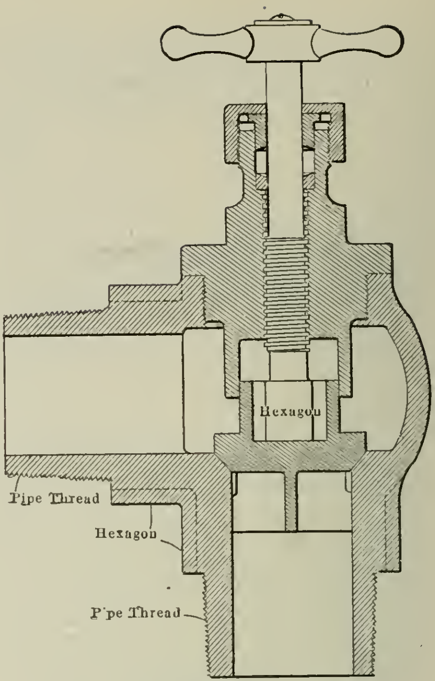


FIG. XI. A HIGH-PRESSURE CHECK AND STOP VALVE.

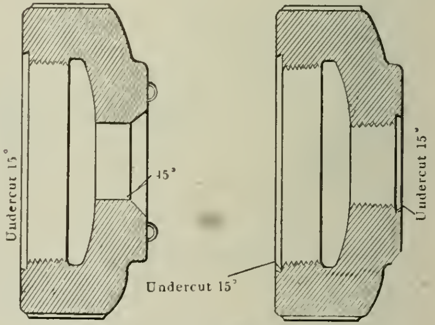


FIG. XII. TWO STYLES OF REDUCING COUPLINGS.

COMPRESSOR FITTINGS.

The fittings shown in Fig. 6 may next be described. A very convenient fitting is the ball and socket joint with loose flange, shown where the high-pressure inlet is attached to the elbow outside the tank, and also where the high-pressure discharge is attached to the head. A detail of the elbow and companion flange is shown in Fig. 10. The thread is not subjected to air pressure, so it is made straight and the flange screwed on by hand. As the joint is against the end of the pipe, there is only one joint instead of two or three as in the case of an ordinary companion flange. The ball and socket feature makes the joint tight even if the parts are not in line. The flange being loose can be readily removed when it is necessary to take that off the side cover of the tank. It is this feature in particular which makes this joint so convenient where it is necessary to slip anything over the end of the pipe before the joint is made. Extra heavy pipe was used in making these joints in order to have sufficient thickness left after threading. Seamless tubing would probably be better than lap-welded pipe, as there would be no seam coming right in the joint. However, extra heavy pipe did not give any particular trouble on this account. It will be noted that the radius at the end of the pipe is made slightly less than the radius of the corresponding socket. This gives in effect a line contact at the smallest diameter of the joint so that it is not necessary to screw up the bolts very tight in order to develop sufficient pressure between the opposing surfaces to hold the air pressure. It may be asked why the companion flange to the check valve was not made in the same way. The reason is that the latter is a field joint and it would not be convenient to have the end of the pipe specially threaded and faced.

It will be noted that the stuffing boxes for the pipes are made separate from the side covers for the tank. On the first machine the stuffing boxes were cast on the covers, but it was found that after the cylinders were assembled in the tank the pipes did not always come right in line with the stuffing boxes. The covers are now cast plain, and are drilled for the pipes after the other parts are assembled and the pipes located.

The style of check valve shown in the discharge pipe is used with slight modifications for either a stop or a check valve on compressor, pipe line and locomotive. A section of one of these valves is shown in Fig. 11, and it will be seen that it is the same style as an ordinary locomotive check valve. The stem may be used to turn the disk and thus grind out any dirt which may have lodged on the seat, or the valve may be locked shut. When used as a stop valve the hexagon on the stem is turned off round. The stem of a stop valve of this style gave way under pressure, shortening and increasing in diameter and changing the pitch of the thread. The stem that failed was made of yellow brass bar. It was replaced by a cast-bronze stem which stood all right. The stress in the stem where it failed figures out about 4,000 pounds per square inch with 800 pounds pressure. The bodies are made of red brass and the stress in the body at *T*, assuming the shape

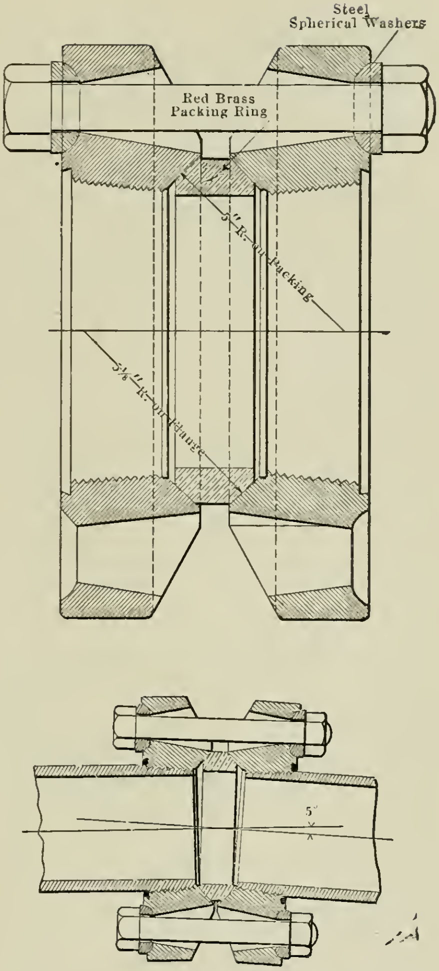


FIG. XIII. A FLANGE UNION FOR 1000 POUNDS AIR PRESSURE.

to be spherical, figures out 2,000 pounds per square inch. Neither of the above stresses were, however, figured out when the valves were designed; they were simply proportioned according to the judgment of the designer.

PIPE LINE FITTINGS.

As explained above, quite large pipe is used in order to act as storage; the sizes most commonly employed being 4, 5, or 6-inch. Very much smaller pipe would do simply to transmit the air, so that it is customary to use 1½ to 3-inch pipe from the compressor to a point outside the engine room where the large pipe begins. Small pipe is also used where it is necessary to pass under and over the railroad track, or at any place where it would be difficult to get around with large pipe. Fig. 12 shows two different styles of pipe caps or reducing couplings for connecting 6-inch pipe to 2½-inch pipe. The companion flange for the flange connection is made the same as the one shown on the check valve in Fig. 6. For this small connecting pipe extra heavy pipe and steel ammonia elbows are used.

As there is usually at least a mile of large pipe, the question of cost becomes an important one; while extra heavy pipe would doubtless be quite satisfactory, it is stronger than necessary, and is quite expensive. Standard pipe is hardly strong enough. There is, however, a grade of pipe between standard pipe and extra heavy known as full-weight, or line pipe. What is known as standard pipe is actually about 10 per cent. lighter than the weights given in standard lists. Full weight, or line pipe, is, however, of the dimensions and weights shown in lists for standard pipe. (This is the explanation a pipe salesman gave me.) This does for storage pipe very well, although there have been a couple of instances where some lengths of this pipe split in service. In one case a piece of 5-inch pipe carrying 900 pounds pressure burst in cold weather without apparent cause. In another case a car ran into a 4-inch pipe carrying 850 pounds. It broke where it was struck and also at the end, five lengths beyond where it was struck. The results of the split were not, however, very serious. The H. K. Porter Company got a special pipe for this purpose made from selected skelp and very carefully worked. This seems to give most satisfactory results.

The couplings used are of a special type made extra heavy with long threads and recessed for calking with lead. If the pipe is screwed up properly there are, however, no joints which it is necessary to calk with lead. When screwing up 4-inch pipe, for instance, there will be a gang of about seven men, six of them with three pairs of heavy pipe tongs screwing in the pipe and one man at the joint. The pipe which is already screwed up is held from turning by a clamp.

It is not found necessary to make any special provision for expansion in these pipe lines.

For flange unions in the pipe line the ball-joint flange union shown in Fig. 13 is a very handy fitting. As it permits a movement of 5 degrees in any direction, it may be used wherever there is a small change in the direction of the pipe line. Where a greater change in direction is required the pipe is bent; if the bend is not exactly correct the difference may be conveniently made up by one of these flange unions. A style of high-pressure flange union very commonly used has a babbitt packing ring. This is liable to leak after the pressure has been pumped up and lowered again, and have to be tightened occasionally. The pipes must also be exactly in line, or they will leak. With the flange unions shown in Fig. 13 these difficulties do not exist. The erecting men like them very much on account of their convenience when laying crooked lines.

At suitable points in the pipe line, say about a mile apart, are located stations for charging the tanks of the locomotives. Fig. 15 shows a charging station and the charging device on the locomotive. The charging station consists of a tee, a charging valve, two swing joints, the "ball" of a ball-and-socket-joint, and three short pieces of pipe. The charging connection on the locomotive consists of the "socket" of the ball-and-socket joint, a clamping screw, a check valve, and the necessary pipe connections to the tank.

A flange tee for a charging station is shown in Fig. 16.

The check valve on the locomotive is shown in Fig. 11. The handle is very essential on this valve; if a little dirt lodged under the seat in charging the locomotive all of the air would blow out of the tank before the valve could be fixed. With the handle the disk can be turned to grind out the dirt. The charging valve shown is similar to the check valve, but with a round end on the stem instead of a hexagon one, and with a long "double-ball" handle. A swing joint is shown in Fig. 17. This, it will be seen, combines a swing joint and two elbows. The use of the split ring enables it to be put together without having the stuffer, rings, etc., large enough to put on over the large end of the elbow.

Fig. 18 shows the ball-and-socket joint made by Deck Brothers, Buffalo, which gives good satisfaction for high-pressure air. It is made of brass and has a screwed instead of a bolted follower. The male half is a nipple instead of an elbow, so it does not require the split ring. An elbow must be used with this swing joint to make it complete for use on a charging station.

Fig. 19 shows the ball-and-socket joint and clamping screw. With the charging station shown the locomotive may stop within about 3 feet on either side of the station, that is, at any point in a distance of about 6 feet. A common form of charging station used in the coal mines of the United States consists of three "Moran" ball joints, a special threaded union to connect the locomotive, a charging valve and a "bleeder," which is a small valve to let the air out of the piping after the charging valve is closed so that the union can be unscrewed with a wrench. As the ball joints permit movement in a vertical as well as in a horizontal direction, they are usually counterbalanced with rope, pulley and weight. With this style of charging station it is necessary to stop within a foot or two. The charging station illustrated herewith does away with the necessity of counterweight, bleeder and wrench, allows greater latitude in stopping, and thus reduces the time required for charging from one or two minutes down to half a minute.

LOCOMOTIVE JOINTS AND FITTINGS.

The storage tanks on the locomotives are designed for much higher fiber stresses than would be permissible in a steam boiler. There are no strains due to unequal expansion, no corrosion due to bad water, no danger of low water allowing the plates to be weakened by heat, no such tremendous storage of energy as in the hot water in a boiler, and no chance for a large increase in pressure. For these reasons the tanks are designed for fiber stresses of about 20,000 pounds per square inch. The 36-inch x 10-foot tank shown in Fig. 20 has a riveted joint of 85 per cent. efficiency, and with 800 pounds air pressure

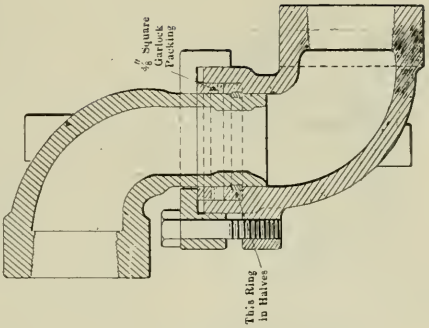


FIG. 17

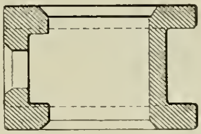


FIG. 16

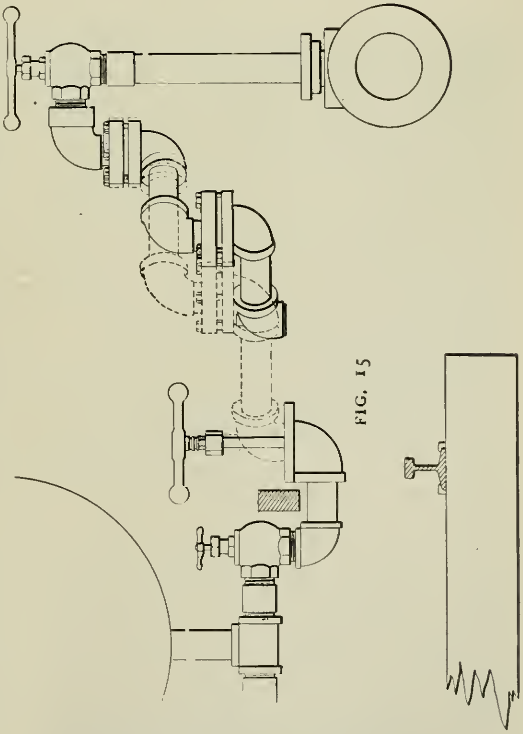


FIG. 15

CHARGING DEVICE, TEE AND SWING JOINT.

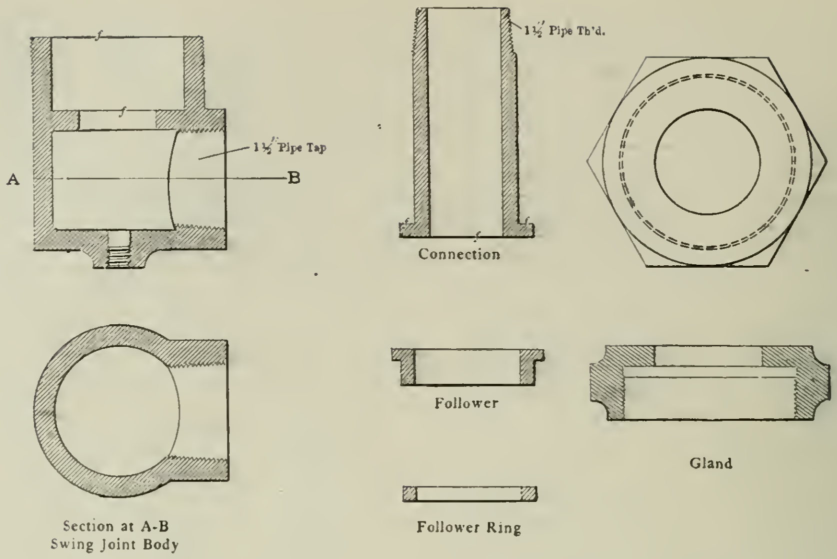


FIG. XVIII. DETAILS OF A 1½-INCH "DECK" HIGH-PRESSURE SWING JOINT

the stress figures out 19,360 pounds per square inch. Tanks 30 inches in diameter with welded longitudinal seams for 1,000 pounds working pressure were made ¾-inch thick, which figures out 20,000 pounds per square inch fiber stress, or, if only 90 per cent. is allowed for the welded joint, 22,222 pounds per square inch. Tanks 32 inches in diameter with welded longitudinal seams for 1,000 pounds working pressure were made 13/16 inch thick, which figures out 19,700 pounds per square inch for a 100-per cent. joint.

These tanks were all made in England and were fine looking pieces of work; heads and manholes were evidently flanged by hydraulic press, and the welded seams were scarcely visible. The tanks with welded longitudinal seams were cheaper than those with riveted longitudinal seams.

The method of fastening the tanks to the saddles is important. At one of the coal mines in Pennsylvania I was told that three different methods had been used on their locomotives. The first locomotive had the saddles secured to the tank by cap screws with straight threads, the second one had cap screws with taper threads, and later ones had taper bolts. The straight threaded cap screws leaked and were finally replaced by taper bolts. The Canadian locomotive had taper bolts put in as shown in Fig. 21. It was not found necessary to even calk a single copper washer.

The stop and reducing valves between the storage and auxiliary tanks are a most vital part of the locomotive. Fig. 22 shows one of these sets of the latest design. It consists of

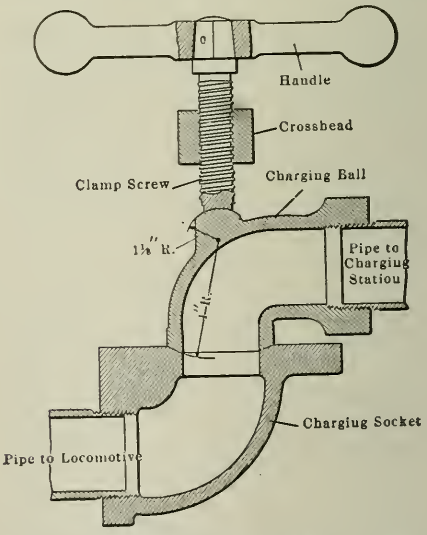


FIG. XIX. BALL JOINT WITH CLAMPING SCREW FOR A CHARGING STATION.

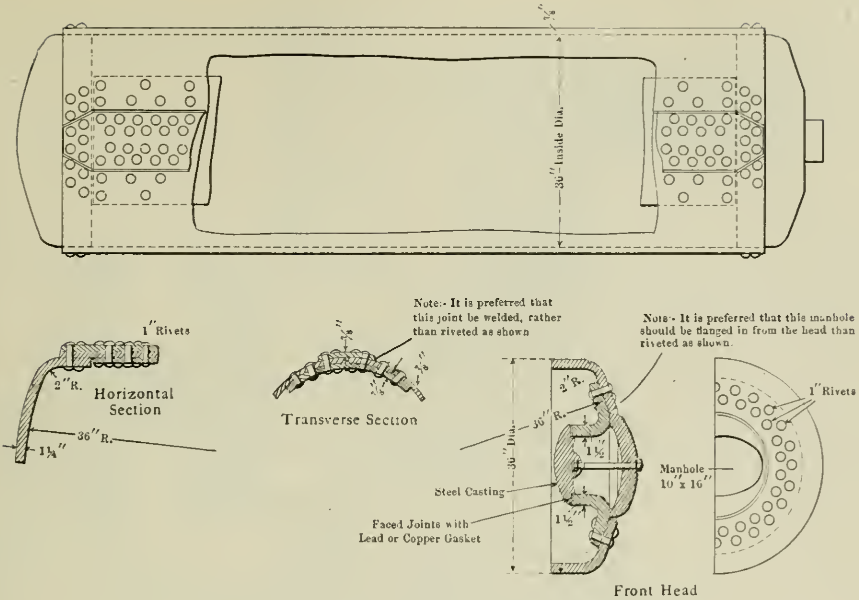

30" Inside Dia.
1" Rivets
2" R.
Horizontal Section
36" R.
1¼"
Transverse Section
Note:- It is preferred that this joint be welded, rather than riveted as shown
Note:- It is preferred that this manhole should be flanged in from the head than riveted as shown.
30" Dia.
Steel Casting
Faced Joints with Lead or Copper Gasket
1½"
Manhole 10" x 16"
1" Rivets
Front Head

FIG. XX. AIR TANK FOR 800 POUNDS PRESSURE.

a hand stop valve, an automatic stop valve with its auxiliary valve and a reducing valve. Of the set shown in Fig. 22 the Foster Engineering Company furnished the automatic stop valve and the reducing valve, but the hand stop valve and the auxiliary valve were built in the Canadian shops.

The hand stop valve is only used in case the other valves require packing, or minor repairs. It can be used, however, instead of the automatic stop valve or instead of the reducing valve if either of them should be temporarily disabled. The automatic stop valve shuts off the high-pressure air when the pressure rises to 160 pounds in the auxiliary tank, and opens again when the pressure falls to 140 pounds, thus protecting the reducing valve from wire drawing when little or no air is being used. Ordinarily it will close just after the throttle closes and open just after the throttle opens, thus relieving the reducing valve when the locomotive is standing. The reducing valve is perfectly balanced, there being no differential unbalanced area as in the case of an ordinary balanced throttle valve.

It will be seen that this set of valves is of the piston construction throughout; that is, there are no diaphragms. The first valves made by the Foster Engineering Company had diaphragms in all the valves. At several mines in Pennsylvania which I visited there was complaint of diaphragms breaking. The matter was taken up with the Foster Engineering Company, with the result that on the Canadian valves they eliminated the diaphragms, first on the auxiliary valve and the automatic stop valve and then on the reducing valve. In reply to a recent inquiry for their opinion as to the value of this change the Foster Engineering Company wrote:

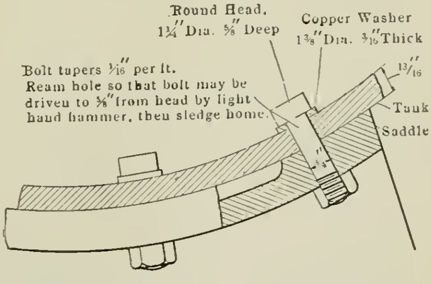

Round Head. 1¼" Dia. ⅝" Deep
Copper Washer 1⅜" Dia. 3/16" Thick
Bolt tapers 1/16" per ft. Ream hole so that bolt may be driven to ⅝" from head by light hand hammer, then sledge home.
13/16"
Tank
Saddle

FIG. XXI. PNEUMATIC LOCOMOTIVE BOLTS.

"We agree with you that the piston construction is a radical improvement over the old diaphragm construction for this service. We have noted in the past that where dia-

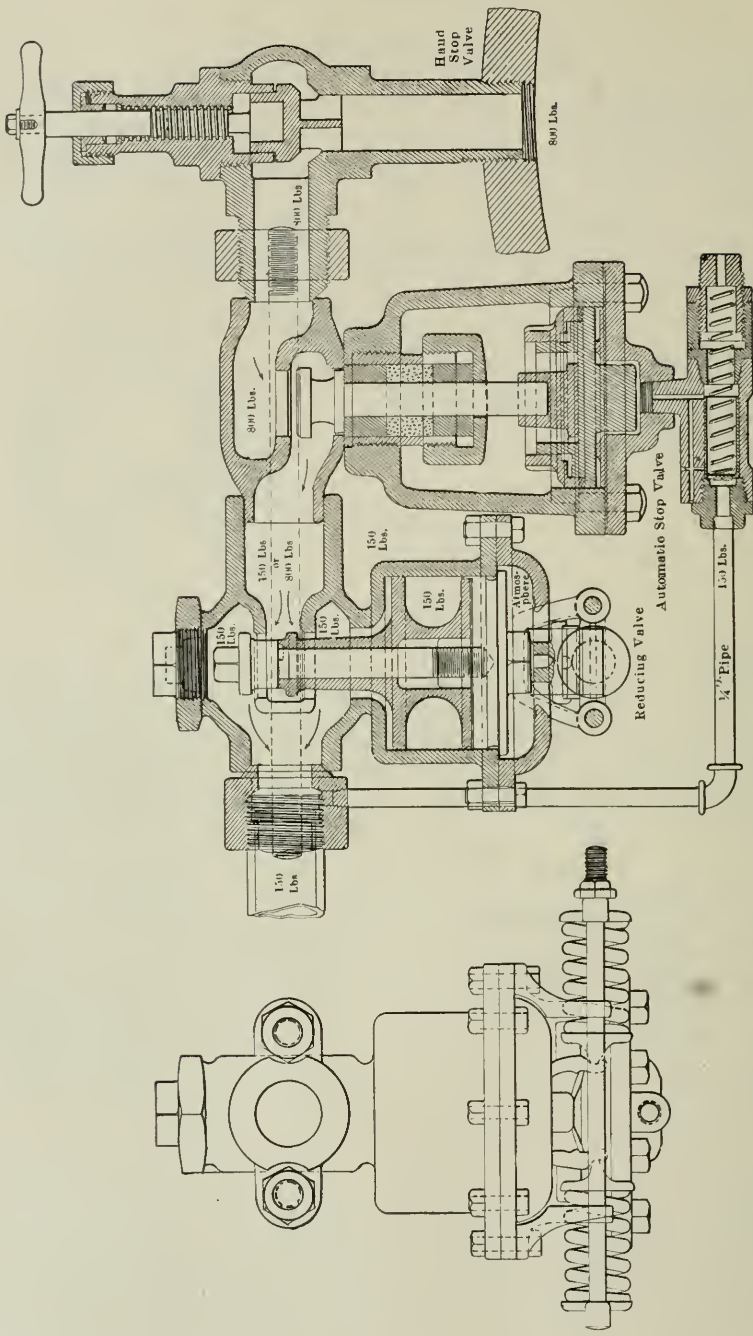


FIG. XXII. PNEUMATIC LOCOMOTIVE STOP AND REDUCING VALVE.

phragms are used there is a tendency to crystallize and destroy the life of the diaphragms, practically throwing the valve, after some little time, out of commission— a condition that is, of course, not experienced in the use of the piston-actuated type. For this reason we believe the piston-actuated type in actual service will outlast the diaphragm type ten to one."

After passing the reducing valve, the compressed air can no longer be considered as at high pressure, but the style of throttle valve may be of interest. It is shown in Fig. 23, and is of the pilot-valve type; both disks being well guided. It has been found to hold the pressure well, to give good control and to work easily. The body of the valve forms also an elbow and a head for the auxiliary tank.

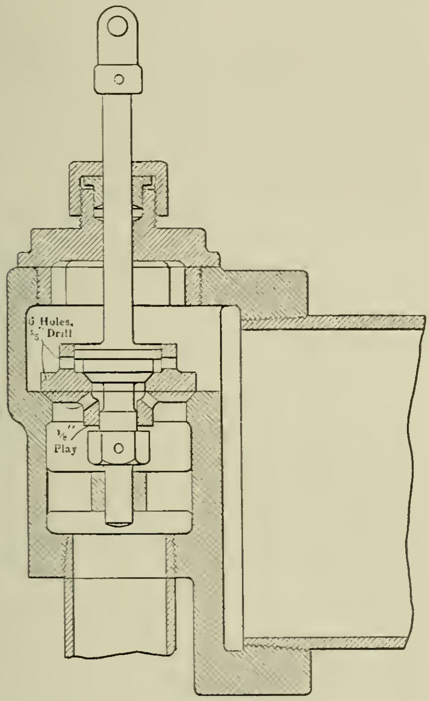


FIG. XXIII. THROTTLE VALVE FOR A PNEUMATIC LOCOMOTIVE.

A few miscellaneous high-pressure fittings are also illustrated. Fig. 24 shows how a coil of copper pipe in a tank is connected to the exterior piping. The fitting shown combines union, elbow, tank connection and connection to the copper tube. The fitting shown was used for only 350 pounds pressure, but would probably be good for 1,000 pounds pressure or more. The manner of connecting to the copper tube is the same as used in automobile fittings for ¼-inch copper tube (see Fig. 25). This form of connection deserves to be better known; it requires neither threading nor soldering of the pipe; is easily connected and will hold almost any pressure. It looks as though it would be a good way to connect lead pipe to faucets.

CONCLUSIONS.

From experience with the joints and fittings described above it appears safe to draw the following conclusions in regard to air piping:

1. The regular taper pipe thread is a very satisfactory permanent joint. In this connection the following quotation from the Crane Company catalog will be of interest:

"The screwed joint, when properly made, has, to the best of our knowledge, given complete satisfaction, and we are now disposing of more of these for power-plant purposes than all of the other styles of joints combined.

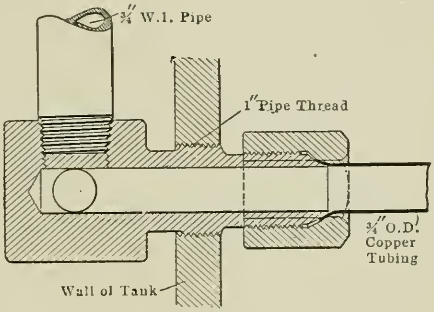


FIG XXIV. TANK CONNECTION FOR ¾-INCH COPPER TUBE.

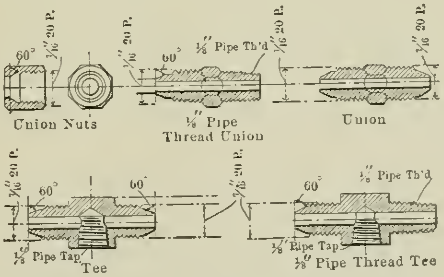


FIG. XXV. UNIONS AND TEES FOR ¼-INCH COPPER TUBE.

"Taking up the objection that cutting the thread on pipe weakens it, we will say in explanation of this that the part of the pipe where the thread is cut is always strengthened by the flange or fitting into which the pipe is screwed, and, in many destructive tests which we have made the pipe has never burst where the thread has been cut, but always burst longitudinally some distance from the thread; nor do we remember of ever having received a complaint of the pipe giving way at the thread.

"We make high-pressure joints as follows:

"The flanges are screwed up by power on a long taper thread cut to a true standard, until the pipe projects through the flange, great care having been taken in the tapping of the flange and the threading of the pipe to the correct size, so that same will screw up to the shoulder in the flange and not expose any part of the thread, which would form a weak point in the pipe line. We also take the greatest care to have the threads perfectly clean, which is one of the secrets of making a tight-screwed joint. This matter, we think, has been overlooked by a majority of mechanics in this class of work. The length of pipe is then placed in the machine and the ends of the same turned off flush with the face of the flange. A light cut is also taken off the face of the flange at the same time to insure its face being perfectly square with the pipe."

2. Fittings should be heavy to permit of screwing the pipe in very tight and to resist deformation under pressure. Crane Company also lay special stress on having screwed flanges of good material and very strong.

3. The number of joints should be kept down to a minimum. It will be noted that practically all of the fittings illustrated are combination fittings, thus reducing the number of joints.

4. Flanged joints and threaded unions should preferably have metal-to-metal joints with narrow faces and may preferably be made ball-and-socket type. Where the end of the pipe must be accessible the loose-threaded flange is a very convenient connection.

5. Valves should preferably be of the angle type, with narrow metal-to-metal joints and with the disk well guided. From the design of the Navy valve it appears possible to avoid the use of stuffing boxes around the valve stems, which is a source of a great deal of leakage with common valves.—Condensed from *American Machinist.*

TRIED TO MAKE AN AIR RECEIVER IN THE SOLID ROCK

A correspondent of *The Mining and Scientific Press* writes:

Some years ago I had occasion to do some development work on a property where the air compressor was run by water power, and during the low-water season there was not sufficient power to furnish air for one drill. The vein, a very irregular one, was in quartzite, close to a syenite and quartzite contact, and in places irregular wedges of this syenite penetrated the quartzite and would cut off the vein, which would be found again on the other side of these intrusive wedges of syenite. At one point, to determine whether or not it was a persistent contact or only a wedge, a drift was run into the solid syenite foot-wall for a distance of about 150 ft. This was at a point some 1,300 ft. from the mouth of the adit, and some 60 ft. from the surface, measured vertically, and this drift for the entire distance appeared to be without a fracture in the rock and, in fact, appeared as one solid block of granite.

Under the conditions as stated, I thought it would be practical to place a concrete dam about 50 ft. back from the tunnel in the drift and then use the remaining 10 ft. of the drift for a receiver in which to store compressed air. The sides, top, and bottom of the drift were carefully trimmed, to remove all loose rock, and a concrete dam was built in the drift; in this dam a large pipe was inserted, both for a man-hole and for pipe connections; after the concrete had set the compressed air was diverted to the supposed receiver; though the dam was well rammed yet the air leaked through it very rapidly. We then turned off the air, removed the man-hole, and placed a coat of neat cement on the inside of the dam, and for 5 ft. back on the top, bottom and sides of the drift; after this set we again turned in the compressed air, and, as far as could be determined, not a particle of air leaked through the dam. We could readily raise the air pressure in this rock receiver to a gauge pressure of about 45 lb., above which point it would increase very slowly. With the small plant it was impossible to obtain a gauge pressure of 50 pounds. Upon the closing of the intake valve the pressure would decrease, and in about 36 hours time the gauge would again register zero.

EXPLOSIVES AND SHOT FIRING

Professor Thompson of Leed's University recently lectured upon the above topic at Ashby-de-la-Zouch.

In one of the coal mines inspection districts they found, he said, that for the year ending December, 1906 there was not a single accident reported from explosives or shot-firing, in spite of the fact that twenty-nine different kinds of explosives were used and somewhere about three million shots were fired, consuming 1⅛ million pounds of explosive.

They might, he said, regard an explosive used in blasting as a heat engine. The charge placed in the borehole compared with the gas and air mixture in a gas engine. When either was fired a great deal of energy was liberated. In the gas engine the hot air expanding against the resistance of the piston drove the engine doing mechanical work; nearly one-fifth of the total heat might be converted into work. In the shothole the tearing apart and rending of the rock replaced the moving, and the gases expanding against the resistance of the rock gave up their heat in the same way as in the engine. Looked at in this roughly general manner, they saw that if all the heat given out by 1 lb. of gunpowder or carbonite when fired could be converted into work, it would be equivalent to a 24-horse power engine working for one minute, while that from 1 lb. of blasting gelatine would be equal to a 60-horse power engine working for one minute. There was one explosive used in the detonators he wished to warn them against—fulminate of mercury. Detonators were not things to be played with, as the Professor showed by telling of two friends who had, by non-appreciation of this fact, each lost half a hand. Professor Thompson described the different fuses, and then came on to deal with the various Government testing stations, speaking of the deficiencies of our own system. There was no absolutely safe explosive for the mine. All the explosives would fire a mixture of fire-damp and air. They must always assume that an explosive fired in coaldust was dangerous, even with a permitted explosive, and then to make it as safe as possible they must try and let the heat of its high temperature be used up in accomplishing the work required of it. The borehole should be well stemmed. At a colliery they must not, of course, have a combustible fuse for igniting the charge, and Professor Thompson dealt particularly with electric fuses—high and low tension. Spark fuses required 4,000 volts to give a spark of $^1/_{12}$ in. The latest magneto gave a voltage of 80 at the highest speed and with slow ordinary driving, 40 volts., the current being .12 and .008 ampéres respectively. A low tension magneto exploder gave 20 volts at good ordinary speed, and at maximum speed could attain 27 volts. The current at low speeds was .8 ampères and at high speeds .97 ampères. Fuses (present primers) with resistances of about 12 ohms. required about ¾ ampères, though some were fired at .4 ampères. The range of the older tension fuses was more sensitive. In high-tension fuses in which the resistance might vary from 50,000 ohms to 6,000 ohms during measurement and with 13 to 36 volts. the current required was $^1/_{500}$ to $^1/_{200}$ ampères. He preferred the series wiring to parallel where a number of shots were to be fired together. In firing they should always see that they had got full power in the battery. Otherwise there would be missfires.

THE COAL AND FREIGHT TUNNELS OF CHICAGO

Under the streets of Chicago are sixty-five miles of tunnels, the extent of which is not appreciated by the people even of Chicago, perhaps because they do not carry passengers. The tunnel system honeycombs the entire down town portion of the city, reaches as far south as Armour and Archer avenues, as far north as Chicago avenue, and as far west as Green street.

Most of this sixty-five miles of tunnel is about six feet wide and 7½ feet high, the roof being arched. Part of this system is made up of what is known as trunk lines, which are twelve feet high and from twelve to fourteen feet wide. The purpose is, if possible, to make deliveries of coal to the large down-town buildings by means of this tunnel system, thus relieving the dealers of the necessity of maintaining expensive teams for doing the work and, in addition, taking that amount of traffic off the street. As soon as the Illinois Tunnel Company, which owns this subway, began to put parts of its line into operation, plans were made with this object in view. The result has been that the company, to-day, has a direct connection with the Chicago & Eastern Illinois railroad and with the Chicago & Alton railway, while coal handling elevators have been put in some of the biggest down-town buildings, among them those of Marshall Field & Co. and the First National Bank.

The company will soon have 250 small locomotives to work under ground and 2,500 of their small cars or lorries, which will be handling all kinds of traffic, but especially mail and coal. Arrangements have been made to increase this equipment as fast as the need arises. The difficulty of making this sort of installation is seen at once when the statement is made that the top of the tunnel is fully thirty-three feet below the ground in all parts of the city. Where the tunnel is only 7½ to eight feet in height this makes the average space between the floor of the tunnel and the street level forty-one to forty-two feet. The company has passed under the Chicago river fourteen times at which places it has dropped down to a depth of sixty-three feet below the average street level. The tunnel, at this depth, is so far under the surface of the ground as to be below all of the sub-cellars of the various establishments.

DIGGING UPWARD.

When it becomes necessary to make a connection with any of the larger buildings in order to put in a coal handling, it is necessary, of course, to burrow up from the tunnel into the basement of the building and then establish some kind of connection which will get the coal conveniently into the fire room. The company has already a number of these elevator plants installed, one being practically a model for all.

The arrangement for handling coal from these cars into the boiler room of a big building is not dissimilar to the arrangement in vogue at the transfer plant of the Dering Coal Company at Peoria, Ill. The car, which has a hopper bottom, comes up to the designated place on the track and dumps its load of three and a half tons of coal into a track hopper. The fuel is fed from there into a bucket conveyor which hoists the coal up to the top of the shaft and it is there turned over to a belt conveyor of some sort located at a height equal to the top of the boiler in the building. The subway car which carries the coal is, under ordinary circumstances, enabled to do double service, because from the level of the floor on which the boiler equipment is located a chute carries the ashes out from the fire room and dumps them into the car just unloaded. By this plan the equipment of the company is able to do double service and consequently gets loads in both directions.

Underneath the tracks of the Chicago and Eastern Illinois and immediately over the tracks of the Illinois Tunnel Company are a number of track hoppers each of which has a storage capacity of 150 tons. Coal, to be delivered into these storage pockets, must, for convenience sake, be shipped in hopper bootom cars. The railroad car is placed immediately above a chute which leads down to the track hopper. This hopper, in turn, has a chute which leads down and opens immediately above the track of the tunnel company. The pressure of the coal and the size of the lower opening make for almost instantaneous loading of the fuel, as is shown by the fact that on a recent occasion three and a half tons of coal were loaded into a tunnel car in two sections.

HOW TO GET A FRANCHISE.

In obtaining the consent to build this tunnel the president of the company, who was interested with a number of friends in an independent telephone, obtained a grant for a telephone subway. He made it appear to the City Council that he wanted to use these subways for the purpose of facilitating the laying of telephone wires underground. At the time the ordinance went through the City Council no suggestion was made of the possibility of handling freight in this subway, the grant merely giving the tunnel company the right to place telephone wires and transmit sounds, signals and intelligence by means of electricity or otherwise. It was soon determined that under the head of intelligence the company could handle both mail matter and newspapers and since the latter came really under the head of freight the operations of the company soon spread from mail matter and the newspapers to carrying package freight and now to the transportation of coarse freight—coal and ashes.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Established 1896

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ELECTRO-PNEUMATIC POWER TRANSMISSION

The power problem is *the* problem of industrial achievement and material progress. Cheap and readily available power makes the opportunity of enterprise and industry, and when it is appropriated and employed values are produced and wealth accumulates. All our power coming ultimately, as far as we now know, from the energy diffused by the sun, the function of the entire series of operations and devices this side of the sun by which this power is made to do the work, in detailed aplications, large or small, of the engineer and the mechanic, may be said to be entirely that of transmission. The development, as we term it, of power by the combustion of coal, the generation of steam and the application of its expansive energy to produce forceful mechanical movement, is only a detail of the transmission series. The employment of falling water which has been drawn up by the sun to turn our wheels is only a less tortuous channel of transmission than the other.

Generally, neither of these two beginnings of the familiar lines of transmission bring the power all the way to the actual work without still other means, the first operation being usually a dividing up and distribution of the power of the larger initial units. For this end of the work other agencies come into play, and the most active and prominent—the one in this age insisting upon being first thought of where anything requiring power is to be done—is the electric current. It is scarcely an impertinence now, when electricity is not employed for any new undertaking, for its friends to be inquiring why not. And yet electricity is not best or most effective for every line of power employment. For some important and responsible operations compressed air seems to be, and seems likely to remain, the most desirable and satisfactory; but even here the habit is developing of these two agencies working together and each providing additional employment for the other.

Electricity makes it possible to adapt compressed air economically in many cases and under certain conditions. When, as often happens, the power is transmitted a long distance, and when, after all, it is desirable to use both electricity and compressed air in the final workings, it is not necessary to lay both wires and pipes all the way; and indeed, it would not be practical to carry pipes to such distances as wires are now quite commonly laid. Let the wires carry the power most of the way from the big water power, and then let the electric-driven compressor be located within a reasonable distance from its work. Circumstances must determine the details of this arrangement, and especially the location of the compressor.

Generally speaking, if a large volume of air is to be used, it is best to install large units in a suitable power house instead of distributing smaller machines here and there for the saving of some lines of piping. The piping should not be made a bugaboo. There is no difficulty in making and keeping it tight, and the piping makes a cheap reservoir for the air. As the air is always used in more or less irregularity, the fluctuations of consumption can be better taken care of in the concentrated plant than in the scattered and isolated units. The electric air drill has made it possible to use electricity as the sole transmitter of power in mining operations. No lines of piping are employed, the wires leading right to the drill pulsator; and this arrangement, and the success of it, has led to the suggestion now current of distributing small electric-driven compressors in different locations in a mine for driving percussion drills of the familiar air-pressure-driven type. The power cost of such an arrangement would be four of five times that of the electric air drill, to do the same work, not to speak of the many other objectionable features.

THE UNCONQUERED AIR

The following, which is a leader from a recent issue of *The Engineer* (London), is well worth reading as a plain statement of the present status and prospects of the aëroplane and its kindred devices.

For many months mechanical flight has held universal attention. The popularity of the dirigible balloon has been displaced by the aëroplane, and the work of Santos Dumont and Spencer is forgotten in the exploits of the Wrights, Farman, and Delagrange. The conquest of the air is proclaimed by journalists, and columns of our daily papers are devoted to a subject which not a decade ago provoked ridicule and contumely. That is a kind of change to which the engineer and the scientist have always been accustomed; the "noble insanity" in them which "creates" what it cannot "find" is accounted real insanity by the thousands who are unable to comprehend the workings of their minds. But in these sudden changes there is always the same lack of balance, the same want of moderate and quiet thinking. From an extreme of disbelief a sudden spring is made into over-belief. The inventor finds himself a preacher at a revival; he effects something that the public deem a miracle, and straightway their want of any belief at all is changed into a belief in everything. They know neither moderation nor reason.

If anyone considers these observations too severe let him look at the papers for the last few weeks and then consider the results that have been actually achieved. Take first the winning of the Deutz Archdeacon prize by Henry Farman in Paris on January 13th. Farman under atmospheric conditions which had to be watched, waited for and seized at the moment, sent word to the judges that he would attempt a flight. The judges assembled, a course was marked out, and the "aviator" started. He made the circuit laid down in the conditions and won the coveted prize. The flight was about one mile long, and he was in the air one and a half minutes! Attempting to repeat his experiment on a later day his machine was wrecked. He had conquered the air by a successful invasion—when the wind's back was turned—lasting one and a half minutes! What the two Wrights have actually done we do not know with any certainty. They have successfully sailed through the air with a self-propelling aëroplane, but how long the flight, how far, how fast we do not know. What we do know is that, like Farman's, their machine finished a journey by a descent of unpremeditated suddenness. Finally, we have the record beating flight of Delagrange. At Rome he circled nine and three-quarter times—note the lack of completeness expressed in the three-quarters—round a rectangular enclosure. The distance he covered was 15 kiloms (9.3 miles), and he was master of the element for 15½ minutes! The next day he essayed to repeat his success; the weather was not so favorable, and his machine also met with an accident. Taking all these official flights together, not one hour has been spent in the element that we are told has been conquered, and the minutes of success have only been snatched when the conditions put everything in the hands of the "conqueror." We have shown these facts in the least favorable light to enforce the truth that we have no more right to say these men can fly than the beginner who makes a sudden dash and covers a few yards before he falls off has a right to say he can walk the tightrope. But we need not tell engineers that we are very far indeed from undervaluing the successes, short and fitful as they are, that have been achieved. A flight of ten minutes in an aëroplane is worth days of doubtful soarings in navigable balloons, and we give very hearty praise and congratulation to the men who have made the flights. But we must remember that the aëroplane is, and from its nature must remain, a very imperfect vehicle for flight. If we turn again to our daily papers we shall find that the admiration of the reported increases with the speed of the aëroplane. Here is a strange perversion of judgment sprung from the motor car and the railway train! The thing to praise in an aëroplane should be slowness. As its speed increases all its other qualities increase in manifold. Its sustaining power and its stability depend upon its velocity; reduce that and it comes tumbling to earth. It is like a cyclist on a tight rope without a pole or a parasol. Let him stop his machine and he falls into mid air. We do not hesitate to say the day will be seen when the biggest prize will be offered to the aviator who takes the longest time in going round the course—the race shall be to the slowest. That is the object which the inventor must keep in view, the object for which he must work. The problem of flight will not be solved so long as a high forward velocity is the only means of maintaining position in the air. Until we can go slow or fast at pleasure, flying will remain nothing more nor less than a sport with a very limited utility for military purposes. It will be impracticable to start or stop with ease, and impossible to manœuvre with the exactness that is required in a "useful" vehicle. Can we imagine the condition of naval architecture if ships were built only on skimming dish lines and sank to the bottom if their speed dropped below 30 knots? The position is precisely the parallel of the aëroplane.

That the aëroplane will sustain weight has been known for very many years; that by careful proportioning and planning it may be made to bear a man through the air has been proved by hundreds of experimenters; that it may be made self-propulsive and self-supporting has now been demonstrated. Aëroplane after aëroplane may now be repeated almost as readily as balloon after balloon. But we shall get little if any further by such repetition. The aëroplane is full of disabilities, and the search for other means of achieving flight must not be neglected.

THE ENGINEER AND THE CONSERVATION OF RESOURCES

By Willard A. Smith.

Engineering has had many definitions—most of which qualify and enlarge rather than actually define. In a very real sense we may speak of it as the science of economy, of conserving the energy, kinetic and potential, provided and stored up by nature for the use of man. It is the business of engineering to utilize this energy to the best advantage—so that there may be the least possible waste. Nature has stored up combustibles in the shape of coal, oil and wood, the force of gravity in running or elevated water, the force of the wind, solar radiation, tidal power, and animal or muscular energy. These are the materials of engineering, to utilize which to the best advantage calls for the best preparation possible for the engineer to attain.

With the lavishness of newness, little recking our rate of development and its terrible destructiveness, we have gone on in this country along the lines of least resistance until the end of some of these resources is almost in sight. The President has called a conference of Governors of States to consider what can be done towards conserving the coal deposits, the forests and the water supply, all of which are disappearing with startling rapidity. The common weal calls for engineers prepared to meet the situation; for men who shall know how to make every possible unit of energy useful by improved machinery and methods; who can substitute other sources of energy for those which are vanishing; and who can plan and organize a general policy looking to the largest immediate returns without sacrificing the future of the race.

Our country calls for such men and they are needed in the councils of the nation. The business man has broken into the preserves of the lawyers in legislative halls and administrative offices. Why should not the "live-wire" engineer be there also? Why should he not be a maker of policies, instead of a mere technician, retained to work disadvantageously under the direction of the incompetent?

We sadly need in public affairs some of these qualities which he must possess and cultivate. The engineer must be an accurate man; he must know his data and his formulas; and his calculations must be exact. He is needed in politics to combat its dishonesty and slouchiness of thought and method. The engineer must be honest with himself—a kind of honesty all too rare. These qualities fit him rarely for the consideration of problems of national import which are not usually considered as engineering.

The engineer's habits of thought, carried into political economy, may make of it a higher grade of engineering. Albert Fink, the great civil engineer, spent his maturest years in organizing and directing the railway traffic associations of the country, eliminating waste and dishonesty and endeavoring so to unify the great volume of transportation that it might give the public the best service at the lowest cost, and yet permit railways to make such earnings as to insure further development. In this work, he often told me, he was still the engineer. He had graduated from one life class to another, finally reaching, as he deemed it, the highest field of engineering.

Such an engineer will not be content with simply estimating the construction possibilities of any proposed physical development. He will examine into the actual necessities for it and the probabilities of adequate return; considering that the public money should not be sunk merely for the benefit of speculators and contractors or to promote the fad of a class of engineers.

For instance, there is now before the country a proposition for the investment of enormous sums in the improvement of waterways. These are advocated by three classes—men having an itch for figuring in the public eye, politicians seeking an issue to justify their existence, and engineers interested in the technical features of the proposed work. So far as I can see, there has been no careful investigation of the traffic which can possibly be developed; and in most cases it is not only now an unknown quantity, but the conditions for future development are utterly lacking. Ought not the ideal engineer to be an economist, who shall dare to say when engineering development ought not to be undertaken as well as when it ought? *From address at installation of Dean Goss, University of Illinois.*

RUNNING A ROCK DRILL

The rock-drill, above other machines, is the most subjected to rough treatment, the more so underground, where, because of the bad light and want of space, and also from the inexperienced hands in which it is often placed it gets more knocking about than is good for any machine, not constructed on the soundest model and of the strongest material.

In some kinds of rock the bit is very liable to stick, and then the workman hammers at it or upon the body of the drill with whatever first comes handy. A blow from a hammer is the quickest way to release a drill, and will do no harm to a first-class machine, but the blow should be given to the steel, and not, as often happens, on the piston rod or machine itself. To illustrate; an instance is given by Davies, who in using machine-drills in a mine in the south of France, where the miners were a hot-headed mixture of Spanish and French blood, had trouble, arising from the men, when the bit stuck, striking the fronthead (stuffing-box) of the drill and often breaking it, perhaps accidentally, perhaps maliciously, since such a break would create a delay arising from the necessity of changing machines. In that particular mine it happened that the miners were much against the introduction of machine labor for stoping. In fact such was their opposition that the drills were set to work under police protection, but, notwithstanding all precautions, the first man who undertook to run one was assassinated, and the roof of the underground superintendent's house was destroyed by dynamite. This opposition arose from their idea that they would be thrown out of employment as soon as rock-drills were set to work.

It is difficult to find and train men well fitted to the work of running a drill. What is wanted is a man of an energetic, ingenious turn of mind, possessed of much patience, who will take pride in overcoming difficulties in his way, and who will not be happy until he has done so. At first, such a man may lose time by puzzling over the job, but, once he gets to know his machine, he will not readily be put in a fix. It is always advisable to have a man available to instruct others when they begin this work. As soon as a drill needs repair, or refuses to work, it should be sent to the surface, as it is a loss of time to undertake to repair it underground, and one is liable, in so doing, to lose some of the fittings.

The machine-man must know how to point his holes and how to fix his support where it will enable the drill to command the greatest number of holes. In operation, if a column or shaft-bar is to be used, place a block of wood between the rock and one end of the bar, though a block at each end is always to be preferred. Fix the bar firmly and rigidly between floor and roof or the walls by means of the jack-screw. Now clamp the drill tightly on it in the required position and square off the rock, where the drill is to enter, at right angles to the travel of the bit. This should be carefully attended to, especially in hard fissured rock, since the bit, under the heavy blow, will glance aside, and not cut down the edge of the hole in line with the travel of the bit. This deviation, if not attended to, will gradually carry the bit so much out of line as to waste the whole effect of the blow in friction, whereupon a bit of smaller size must be inserted. In fissured and troublesome rock, when the drill is allowed to get out of line at the start, it will often cause trouble throughout the entire hole, while *a hole well started is half drilled.*

When the face of rock has been squared, and everything is ready for a start, put in the shortest bit, which will permit a good travel of the feed screw, draw out the piston-rod until the piston strikes the bottom of the cylinder, and screw forward the drill until the bit touches the rock, then give the feed-screw a couple more turns. To fix the bit in its chuck all that is necessary is to force back the piston-rod, then draw it smartly forward, striking the bit against the rock. Then tighten the U-bolt nuts. Permit air to blow through the hose to remove any dirt or grit which may have accumulated, close the throttle-valve, pour two tablespoonfuls of oil into the coupling, bend the hose and connect it to the machine. Oil the rotating gear by removing the screw-plug upon the top cover and the machine is ready to start.

Turn air into the hose from the mains, half-open the valve, when the machine will start and at once begin to cut the rock, and, as the bit penetrates the rock, the machine must be correspondingly fed by the feed-screw. When four to five inches have been drilled, turn on full air, pour water freely into the hole and keep turning the screw-feed as the hole advances. When the short drill has cut as deep as it will reach, shut off the air, get the machine back by means of the feed screw, remove the bit and replace it by the next longer one. Strike the first few blows at half-pressure to bring the bottom of the hole to the shape of the drill, then proceed at full speed as far as that bit will allow, when it in turn must be replaced by a still longer one, and so on to the depth desired.

In running a new machine-drill *with steam,* it may happen that it will not start readily, or at first work slowly. This is caused by the unequal heating of the cylinder and will disappear as soon as the machine becomes uniformly heated. When starting either a new machine, or one which has been laid aside, pour a half-pint of coal-oil into it to remove the gum of the old oil, and, after a few minutes' run, oil with a good suitable oil. Keep the machine properly oiled, take care of it, and you will find it the miners' most useful tool, and one which will last for years with trifling repairs.—*Mexican Mining Journal.*

THE BUSINESS OPPORTUNITY

Labor is cheaper now than it was a year ago, although nominally wages are the same. It is cheaper because it is better.

Materials are cheaper than they were a year ago, not for the same reason that labor is cheaper but in the actual prices that must be paid.

Last year the majority of the dealers in building material had all the trade they could handle. This year business has been fair, as shown by the building records, but there is room for a very considerable improvement.

The one great reason why building operations should be undertaken now or why contracts for supplies should be entered into is that they can be made on more advantageous terms.

Materials can be secured for lower prices, will be delivered more promptly and in a more satisfactory manner than during either 1906 or 1907.

As a general proposition lumber now is being sold for 10 to 15 percent less than during last year. In some cases where the trade is supplied with special woods a reduction to that extent has not been made. However, 10 per cent. probably represents about the general decline in the retail price of building material.

A Cleveland operator has supplied some specific information showing the relative cost of building in 1907 and 1908 which is reproduced herewith:

	1907.	1908.	Percent. of decr'se.
Masonry and grading ..	$1,329	$944	29.0
Plastering	585	313	46.8
Plumbing	640	500	21.9
Heating	730	570	22.0
Painting	530	400	24.5

The foregoing comparative values represent actual figures secured by a gentleman who wished to build. The 1907 prices were made during the latter part of that year and the 1908 prices this month (June).

It is high time the general public informs itself of this condition of affairs and profits by the opportunity now presented, one which probably will not long be available.—*American Lumberman.*

RECORD DRIVING IN SOUTH AFRICAN MINES

With more rock drills for a given area than anywhere else in the world it might be expected that on the Rand some of the world records would be made. Mr. E. M. Weston, Manager, Rand Collieries, Ltd., Brakpan, Transvaal, contributes the following to a recent issue of the *Engineering and Mining Journal,* which is showing its enterprise by keeping in close touch with South African mining operations.

On the Simmer reef, which is about 4,000 ft. deep, the record for driving established on the Cinderella reef has been lowered. The 15th level was advanced 294 ft. in 61 shifts of 10 hours. The size of the drive along the reef was 7x5 ft. One white man and six Chinese operated three Ingersoll-Sergeant 3¼-in. drills on one bar. One round was drilled and blasted each shift, and the average gained per round was 4.8 ft. Blasting gelatine was employed, and 50 lb. was used to advance 4.5 ft. or 11 lb. per ft. Fifty-nine of the rounds needed 14 holes with the usual three-hole center cut to break them; 100 rounds required only 12 holes.

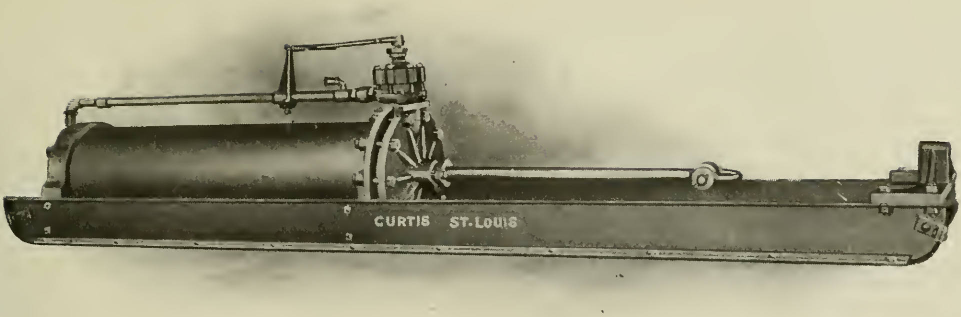
The air pressure at the surface was 80 lb. gage, and owing to the pressure gained at such great depths due to the difference in weight of a column of dense air compressed to 80 lb. in the pipes and the normal air in the mine pipe, friction was balanced and the air was supplied to the machines themselves at 80 lb. This gain in air pressure at about 4,000 ft. equals 10 lb. per sq. in. Water was laid on, and an arrangement was also made whereby the water could be turned into the air pipe, making a spray after blasting and at once cooling the drive and laying the dust.

In comparing these results with those gained in adit driving in America it must be borne in mind that these drives are not straight, that mechanical haulage is not used and that the ground is generally harder and requires more holes and larger quantities of more powerful explosives, while the smaller size of the excavation does not give room for an economical arrangement of holes.

A COAL MINE TIMBER PULLER

The half-tone shows a device of the Curtis & Company Manufacturing Company, of St. Louis, by means of which compressed air is employed for removing timbers from the depleted sections of coal mines to be used elsewhere. The air used is quite inappreciable in comparison with that required for rapidly operating machines, and the saving in timbers will pay for the rig in a short time.

Scarcely any explanation is required. An air cylinder is mounted upon steel skids which can be temporarily secured to track ties or otherwise braced for the pull. The end of the piston rod carries a clevis to which the chain is attached. The chain passes through a guide at the front end of the skids and may lead off in any distance and also at a considerable angle, so that a number of pulls may be made for each locating of the puller. The air supply may be led to the apparatus by the smallest hose in use. The air valve is attached to the front cylinder head so that the operator is always in position to watch the pull. The valve may be opened as gently as may be desired for either movement of the piston and is self-closing when released.



A COAL MINE TIMBER PULLER

A LARGE TROUBLE FROM A LITTLE LEAK

In an enumeration of various experiences of a trouble hunter in a recent issue of *The Contractor* the following occurs:

A Western concern sold a Corliss steam driven air compressor of 2,000 cubic feet capacity. It was set up and started to the entire satisfaction of buyer and seller. After the compressor had been in operation about a month the manufacturers were notified that it failed to regulate and was workng in a very unsatisfactory manner. An expert was requested to come and look into the matter at once. The trouble hunter found everything in perfect order so far as appearances went, but the regulation certainly was poor, and the air pressure varied greatly without apparent cause. Upon closing down in the evening the valve gear was examined, but the cause of the trouble could not be found. Next day's search was equally fruitless. As a forlorn hope the air regulator was taken apart and examined. Nothing could be found upon minute examination that could have caused any trouble. Yet, strange to say, when the regulator had been re-assembled the compressor ran with perfect regulation as if it were working for a prize. The trouble hunter looked wise and said nothing, though he went home mystified. Two months later he was called back again by a repetition of the former trouble. This time before taking the governor apart a most painstaking investigation was made. It was found at last that the air cylinder of the governor, which was connected with the receiver by a quarter-inch pipe, had a leak at the joint, which was made with a cap, so minute that the air blowing through it was not noticed. Yet the quarter-inch pipe not being large enough to take care of the leak without a reduction in pressure, any change in pressure in the receiver did not have its proper effect on the air cylinder of the governor. When this minute leak was stopped the compressor worked satisfactorily and has given no further trouble.

THE LIMIT IN SHAFT SINKING

It may fairly be said that the technique of shaft sinking has undergone such great improvements in recent years, that it is now probably quite equal to any demands that can be made upon it for some time to come. The deepest shafts in the world are in the copper mining district of Lake Superior, where there are at least two close upon 5,000 ft. in depth; with the exception of this district, of a few shafts in the Bendigo district of Victoria, a few at Johannesburg, and some in the Przibram mines in Bohemia, it may be said that there are practically no shafts in metal mines over 3,000 ft. deep, so that the ability to reach considerably greater depths than have hitherto been obtained in most mineral fields may be taken for granted. Indeed, as far as the actual sinking is concerned, there would probably be no serious difficulty in sinking a shaft 10,000 ft. deep, provided that it could be known with certainty that a deposit of ore would be met with of sufficient value to recoup the outlay incurred in such a sinking; in other words, the main problems connected with deep sinking are economic rather than technical. Apart from the difficulties of hoisting and pumping, the main obstacle to very deep working will probably be the effect of the high temperatures that are met with at such depths upon the workmen employed. Men seem to feel the effects of moist heat when the wet bulb registers about 75 degs. Fahr., and must then commence to strip so as to expose a greater surface of the skin for evaporation, and the limits of working power seem to be reached at about 100 degs. Fahr in a moist atmosphere. . It may, however, be urged that the artificial cooling of working places is neither difficult nor costly, and that with the increasing employment of mechanical devices underground, the amount of physical exertion required from the miner is continually diminishing.—Prof. Henry Louis, "James Forrest" Lecture, Institution of Civil Engineers.

COMPRESSED AIR OPERATES THE VACUUM CLEANER

In cleaning cars by the direct action of compressed air the seats and cushions must be removed from the car and blown out. The blowing scatters the dirt and allows some of it to remain in the cushions. If the compressed air jet is used inside the car for blowing out the dirt, the dust and dirt are simply blown from one seat to another and not removed from the car. The vacuum cleaner removes all the dirt from seats and cushions by suction, carries it outside the car through the hose and deposits it in the receiving tank, all without raising a particle of dust in the car.

The apparatus consists of a dust collecting tank so arranged internally as to separate the dust from the air, an air jet vacuum producer mounted on top of the tank, special vacuum hose for conveying the dirt from the car to the vacuum tank and the sucking nozzles. These are made of metal and have from one to three slots in each through which the air is drawn with a rush bringing the dust and dirt with it. The vacuum producer is connected with it. The vacuum producer is connected to the compressed air supply (either the pipe-line or the air brake reservoir on the car) by means of a compressed air hose. The vacuum hose is attached to the side of the tank, and the other end with the tools attached is carried into the car. The compressed air is turned on and regulated by the valve on the vacuum producer until the proper vacuum is obtained. The cleaning tools are then passed over the seats and other parts to be cleaned until the dirt is removed.

NOTES

A small balloon sent up by Prof. Rotch of Blue Hill observatory, near Boston, registered an altitude of 46,680 feet, and a temperature of 111 degrees Fahr. Whether the lowest temperature was coincident with the greatest altitude did not appear.

Diamonds, though extremely hard, are also very brittle and are easily fractured by a sharp blow. If, however, a good diamond is placed between the jaws of a hydraulic press, and the pressure is applied slowly and without jerk, the jaws may be made to meet without the slightest injury to even the edges of the diamond, a perfect impression of which will be found in the hard steel jaws. This interesting experiment, illustrating at once the hardness of one material and the flow of another material also considered hard, doubtless many readers will be trying for themselves.

The R. D. Nuttall Company, of Pittsburg, announces the establishment of a new department to be devoted exclusively to the manufatcure of gears and pinions for air compressors. This company has for some time been supplying gears and pinions for all the standard makes of air compressors. It is owing to the rapidly growing demand for compressed air in a number of important industries that a special department was found necessary. The department will be equipped to turn out gears and pinions for the standard types of compressors upon short notice, and to better accommodate the users of compressors will carry a complete assortment from which immediate shipment can be made.

There died a short time ago in Grass Valley, Cal., a noted character who was widely known in that State for his long and persistent work as a miner under adverse circumstances. He was a pioneer and lost his sight by a blast some 56 years ago. Despite his affliction, Hyman Clendenning continued work as a miner until quite lately, when old age and ill health stopped him. He had a theory about the existence of a rich gravel channel underlying a certain tract of land, and for many years carried on work alone in a tunnel to develop this channel. Quite recently the Jenny Lind Mining

Company struck this channel and is finding it extremely rich. While his theory was proven, it was of no benefit to the blind miner, who had been unable to get assistance to carry his tunnel to completion. So persistent was he, however, that he worked alone, as stated, for many years, and did his mining work with skill, notwithstanding his blindness.

Extensive experiments have been carried out on the Austrian government railways with automatic vacuum brakes on freight trains. A train composed of 70 cars loaded with coal, and weighing 44,000 pounds each, was fitted with automatic brakes. Numerous trials were carried out with this train on lines having different road conditions, and the trials were repeated on a line with gradients of from 3 to 3.1 per cent. In this experiment the train was composed of 70 freight cars and 5 passenger cars, interspersed for observation purposes. Twenty-nine of the total 75 cars carried load, and 46 carried no load. The weight of the train, including locomotive and tender amounted to 1,201.7 metric tons (1,322 short tons) and the total length of the train was 2,620 feet, or nearly half a mile. The results are said to have been very satisfactory. Considering the length of the train, the brake valve on the last car came in action very rapidly, only 2.2 seconds being required for the brakes to be applied on the last car after they had been applied on the locomotive.

Liquir air is used to some extent for blasting purposes in a few German coal mines. It was first used in combination with other materials, but is now used alone. Its explosive power depends upon its property of turning suddenly into vapor at an elevated temperature. If the vessel holding the liquid air is sufficiently tight, a high explosive power is attained. For this reason vessels with a small opening are used for storing it. This characteristic makes it necessary to place the cartridge in place before it is loaded. The cartridges are made of thick phosphor bronze and are loaded so that the pressure reaches 80 lbs. per sq. in. The explosion takes place in 6 or 8 min. after loading. About 30 tons of coal are broken by one shot. The coal falls in blocks about 2 ft. in cercumference. A heavier loading of the cartridge would cause the coal to be broken into slack.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JUNE 2.

889,290. WINDMILL. Albert J. Anderson, Batavia, Ill.

889,398. ROTARY COMPRESSOR. Cassius C. Palmer, New York, N. Y.

889,477. Motor Mechanism. Austin E. Miller, Cheney, Wash.

1. In mechanism of the class described, a reservoir for storing gases under pressure, an explosion chamber in communication therewith, an air compressing cylinder, a plunger therein, a motor having an inlet port connected to the reservoir, means for operatively connecting the motor to the plunger, and a liquid fuel measuring means controlling communication between the pumping cylinder and the explosion chamber.

889,547. DIE-CASTING APPARATUS. Albert G. Rauh and Lawrence Oslen, Indianapolis, Ind.

1. In a die casting apparatus, the combination with a crucible, a charging cylinder, means connecting said charging cylinder and said crucible, and a die situated under and contacting said charging cylinder, of a fluid pressure and a molten metal supplying means, and a lever common to both said means whereby the molten metal and the fluid pressure are alternately admitted into and exhausted from said charging cylinder.

889,794. VALVE MECHANISM FOR WATER-ELEVATORS. J. L. Latta, Hickory, N. C.

1. In apparatus of the class described, a main air valve, a casing within which the valve is arranged, a compressed air pipe connected to the casing, a valve for controlling the movement of the main valve, an air driven motor for actuating the controlling valve, means for connecting the motor to a source of compressed air supply under a pressure greater than that supplied to the main air valve, and means for directing a portion of the exhaust from the motor into said pipe.

889,701. APPARATUS FOR DISINTEGRATING FUEL-OIL. Harry Luckenbach, San Francisco, Cal.

In an appartus of the character described, the combination with a hollow body, of a nozzle therein for discharging compressed air, a pipe for feeding oil opening in front of said nozzle, a pipe connected to said hollow body and a coiled spring in said pipe tapering towards its discharge end, and made with flattened surfaces, substantially as described.

889.883. WIND-OPERATED DYNAMO. Emil J. Johnson, Madrid, Iowa.

JUNE 9.

889,992. VACUUM-BOTTLE AND CASING. Garry P. Van Wye, New York, N. Y.

890,012. PERCUSSION ROCK-DRILL. Robert Anderson, Johannesburg, Transvaal.

890,057. COMBINATION GAS AND WATER VALVE. Herbert S. Humphrey, Kalamazoo, Mich.

890,065. ROCK-DRILL. Moses Kellow, Penrhyndendraeth, England.

890,108. PNEUMATIC RIVERTER. Wilbur H. Van Sickle, Philadelphia, Pa.

890,289. OXYGEN-CUTTING APPARATUS. Henry P. Merriam, New York, N. Y.

890,310. SANDING APPARATUS FOR TROLLEY CARS AND THE LIKE. Charles Snyder, Manayunk, Pa.

In a sanding apparatus, a sand box, a delivery pipe leading into one end thereof, a partition secured to said end of the box so as to have its lower end registered with said pipe, the top end of the partition terminating below the top of the box so as to provide a constricted passage in conjunction therewith, a pair of horizontal air pipes leading into the opposite end of the box, said pipes being spaced apart and being arranged so that one is adjacent the top of the box, and the other is adjacent the bottom of the box, and means for supplying compressed air to each of said pipes.

890,439. ACETYLENE-GAS GENERATOR. James E. McIntire, Columbus, Ohio.

890,488. PNEUMATIC VALVE-ACTION. Harry Bainton, New York, N. Y.

890,516. AIR COOLING AND HUMIDIFYING APPARATUS. James Kelly, Providence, R. I.

890,546. ROCK-DRILLING EXPLOSIVE-ENGINE. August B. Wittman and George L. Rork, Denver, Col.

JUNE 16.

890,620. PROCESS AND APPARATUS FOR INJECTION OF LIQUID FUELS INTO INTERNAL-COMBUSTION ENGINES. Rudolph Diesel, Munich, Germany.

1. A process of injecting fuel into internal combustion engines which consists in injecting a jet of liquid fuel previously oxygenated, into a body of compressed air in the compression space of the engine.

890,671. PNEUMATIC WHEEL FOR VEHICLES. Bryce J. Macaulay, Eastbourne, and James A. F. Hall, Hampden Park, near Eastbourne, England.

890,808. ROD-PACKING FOR ROCK-DRILLS. William L. Smith, Columbus, Ohio.

890,893. WIND-DRIVEN PUMP. Eugene Egleston, Columbus, Ohio.

890,930. AIR-BRAKE SYSTEM. Harold Rowntree, Chicago, Ill.

890,931. AIR-BRAKE-CONTROL MECHANISM. Harold Rowntree, Chicago. Ill.

890,932. AIR-BRAKE EQUIPMENT FOR CARS. Harold Rowntree, Chicago, Ill.

890,933. BRAKE MECHANISM. Harold Rowntree, Chicago, Ill.

890,978. PNEUMATIC DRILL. Martin Hardsocg, Ottumwa, Iowa.

890,987. NOZZLE FOR PNEUMATIC CLEANING APPARATUS. Arthur W. Kindel, Denver, Colo.

890,994. APPARATUS FOR UTILIZING THE FORCE OF THE WAVES OF THE SEA. Peter Morice, Neutral Bay, North Sydney, New South Wales, Australia.

1. In an apparatus for utilizing the force of the waves of the sea, a platform A, one or more cylinders, open at both ends, pendent therefrom, means for automatically controlling the position of the cylinders by the tide, easy fitting pistons or disks within the cylinders, piston rods rising vertically from the cylinders, and means for connecting the piston rods with compression pumps, as and for the purpose set forth.

891,026. VACUUM-PUMP. Joseph Zeitlin, Kensington, England.

891,144. TERMINAL FOR PNEUMATIC-TUBE SYSTEM. Charles H. Burton, Washington, D. C.

891,180. AIR-VALVE FOR RADIATORS. Fred W. Leuthesser, Chicago, Ill.

891,211. AIR-GUN. Augustus H. M. Driver and George Norman, Small Heath, near Birmingham, England.

JUNE 23.

891,290. BLOWING ENGINE OR PUMP. Gustav B. Petsche, Philadelphia, Pa.

2. In a blowing engine or compressor the combination with the cylinder having the chambered end members connected by a hollow central member, said central member having ports formed in it which serve to pass the fluid pumped or compressed from the cylinder into the receiving space formed by the chambers in said end members and the interior of said hollow central member, of the annular reciprocating piston in said cylinder and surrounding said central member, and the outlet valve mechanism controlling said ports located in said hollow member.

891,299. PNEUMATIC STRAW-STACKER. Sherman B. Smith and Harry W. Smith, Hamilton, Ontario, Canada.

891,324. TERMINAL FOR PNEUMATIC-TUBE SYSTEMS. Charles H. Burton, Washington, D. C.

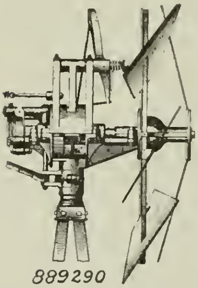
891,341. MEANS FOR AUTOMATICALLY STOPPING TRAINS. George W. Hunt and Jerry Kinney, Pocatello, Idaho.

1. The combination with a truck including an air brake mechanism, of an open-ended tampion holder having communication with the air-brake mechanism and containing a tampion fusible in the event of a hot box to permit of the escape of the air from the air brake mechanism.

891,472. VALVE FOR OPERATING ROCK-DRILLS. George A. Fowler, Georgetown, Colo.

891,473. TUNNEL - DRIVING MACHINE. George A. Fowler, Georgetown, Colo.

891,675. PNEUMATIC ADJUSTER FOR ANGLE-COCKS ON TRAIN-PIPES. William S. De Camp, Chillicothe, Ohio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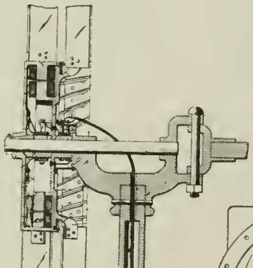
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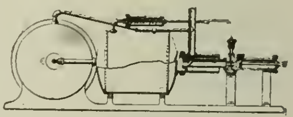
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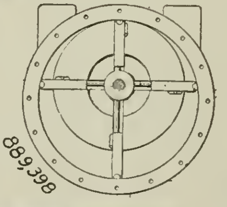
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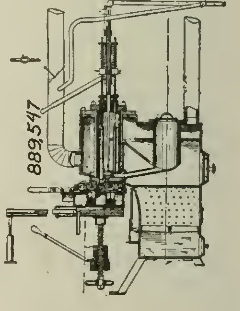
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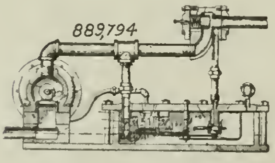
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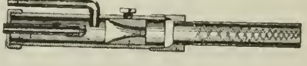
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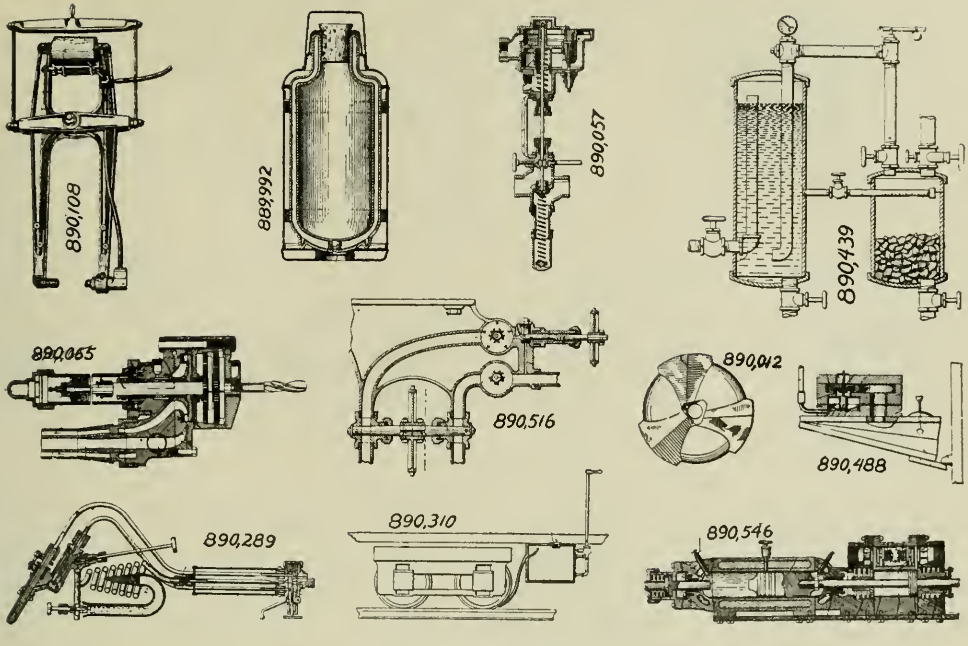
Pneumatic Patents June 2.

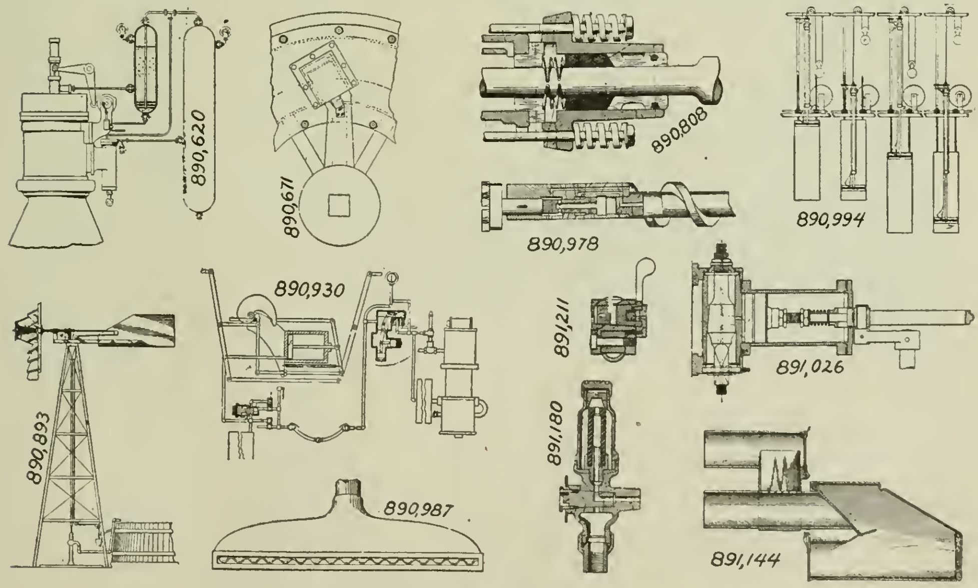


PNEUMATIC PATENTS, JUNE 9.

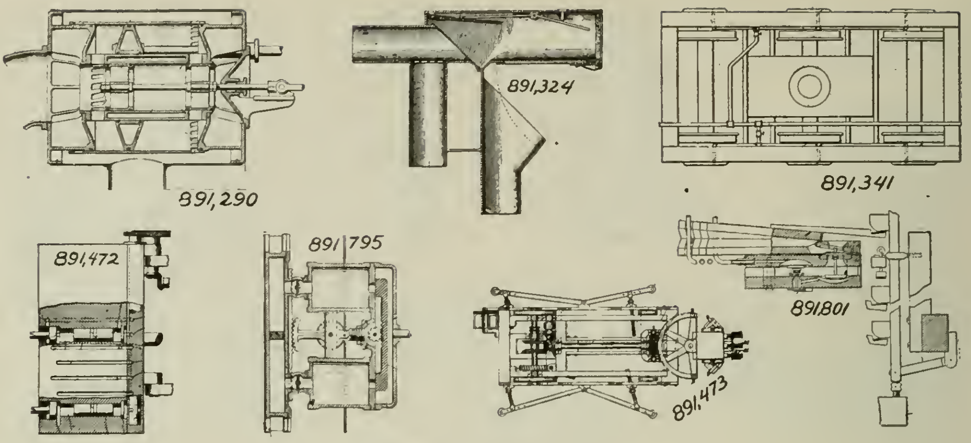
891,676. MEANS FOR CONTROLLING PNEUMATIC SIGNAL-PIPES ON RAILROAD-TRAINS. **William S. De Camp,** Chillicothe, Ohio.

891,795. APPARATUS FOR STEERING STEAMSHIPS AND OTHER VESSELS. **John S. Clarke,** Cleveland, Ohio.

1. A steering mechanism for vessels operating with a liquid control and fluid pressure thereon comprising a quadrant shaped chamber adapted to be filled with liquid, a rudder shaft therein and a piston fixed on said shaft, in combination with means to operate said piston comprising a set of expansion chambers adapted each to be partially filled with liquid and pressure fluid respectively, passages connecting said cylinders with said piston chamber on opposite sides of said piston and a valve for each of said pas-



PNEUMATIC PATENTS, JUNE 16.



Pneumatic Patents, June 23.

sages, pressure fluid inlet openings to the top of said expansion chambers and a slide valve to control said openings, and means to operate all said valves simultaneously comprising a rotatable member adapted to be operated by a cable and an arm controlled thereby, whereby the flow of liquid to and from said piston chamber and the flow of pressure fluid to and from said cylinders, respectively, are brought under a single control.

891,801. MUSICAL-DEVICE PNEUMATIC APPARATUS. Robert A. Gally, Brooklyn, N. Y.

JUNE 30.

891,808. AUTOMATIC DRAIN-COCK FOR AIR-BRAKES. Frederick W. Adams, Selma, Iowa.

891,830. METHOD OF FILLING MATTRESSES. Ferdinand Franke, Clark county, Ind.

1. The herein described method of forming mattresses which consists of directing an air blast into the tick of the mattress to inflate it and discharging the filling material into said tick along with said air blast.

891,831. PNEUMATIC HAMMER. Joseph Frederick, Stroudsburg, Pa.

891,858. BLOWING-ENGINE OR COMPRESSOR. Gustav B. Petsche, Philadelphia, Pa.

892,082. ROCK-DRILLING MACHINE. William Prellwitz, Easton, Pa.

892,098. AIR-COMPRESSOR. James Thornton, Jr., and James Thornton, Sr., Duquoin, Ill.

892,122. FLUID-PRESSURE BRAKE MECHANISM. John H. Bleoo, Brooklyn, N. Y.

892,123. FLUID-PRESSURE BRAKE MECHANISM. John H. Bleoo, Brooklyn, N. Y.

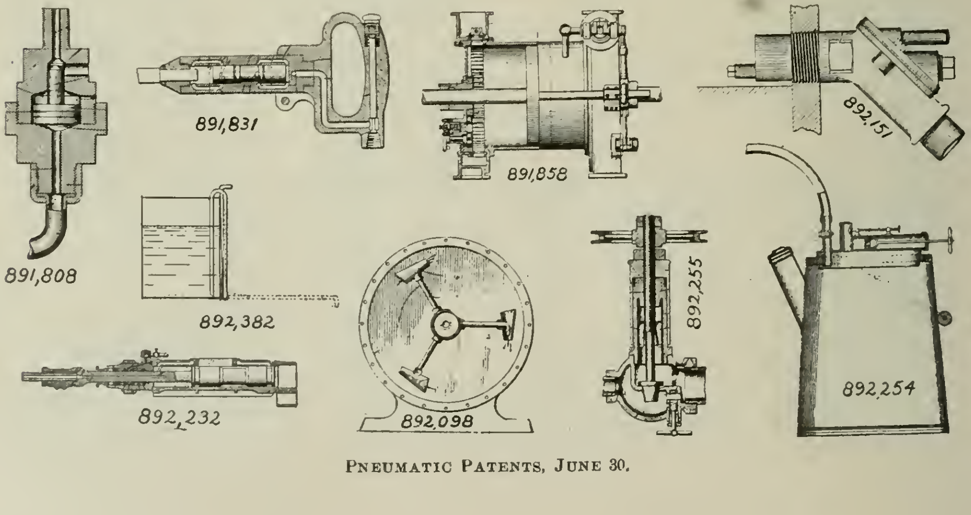
892,151. SANDER. John H. Hanlon, Somerville, Mass.

1. In a pneumatic track sander, the combination of a sander-body comprising an elbow and provided with a clean-out opening, a cover for said clean-out opening and an air nozzle passing through the said cover and lying on the floor of the interior of the sander-body.

892,254. MILKING-MACHINE. Edward Hanson, Kane, Pa.

892,260. COMBINED STREET SWEEPER AND CLEANER. Henry A. Huber, Winnipeg, Manitoba.

892,382. SIPHON DEVICE FOR WITHDRAWING LIQUIDS FROM VESSELS. Albert W. Omond, Bendigo, Victoria, Australia.



Pneumatic Patents, June 30.

COMPRESSED AIR
AND EVERYTHING PNEUMATIC.

Vol. XIII SEPTEMBER, 1908 No. 9

A VARIABLE VOLUNE AIR COMPRESSOR

Varying Delivery by Quarter Loads While Maintaining Full Compound Efficiency.

By H. V. Haight.*

The machine illustrated is a duplex-tandem compound compressor, each side being practically a complete machine. The principal dimensions are as follows: Diameter each, low-pressure cylinders, 25 inches; diameter each, high-pressure cylinders, 16 inches; stroke, 36 inches; revolutions per minute, 85; displacement, cubic feet free air per minute, 3,474; rope wheel, diameter 16 feet; diameter of ropes, 1 inch; number of rope grooves, 18; weight of wheel, 26,000 pounds; weight of base plate, 25,000 pounds; total weight of machine, 110,000 pounds; horse-power of driving motor, 600.

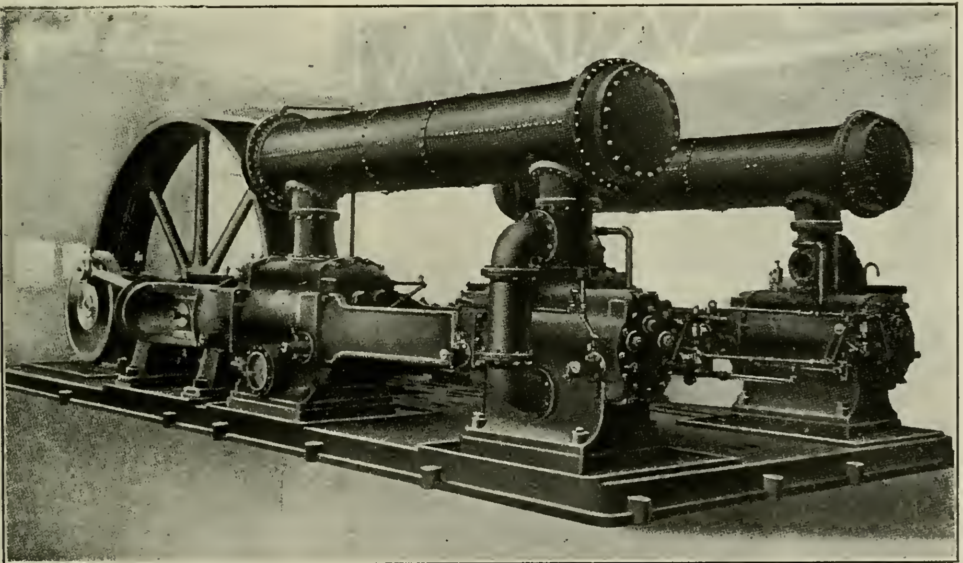


FIG. I. LARGE CANADIAN VARIABLE VOLUME AIR COMPRESSOR.

This compressor was built for British Columbia, where most of the large motor-driven compressors in Canada are located. Practically all of the large motor-driven compressors in British Columbia are driven by ropes, on the Dodge-American system, with long centers, usually 55 feet. The diameter of the ropes is usually 1¼ or 1½ inches. Fig. 1 is not the one belonging to the compressor, as its own wheel had already been shipped. It has a double set of arms, and there is an arm close to the joint on each side to support the heavy lugs. The net area of the bolts in the rim joint is about 23 per cent. of the net area of the rim. At the rated speed of 85 revolutions per minute the velocity of the rim is 4,250 feet per minute and the calculated stress is 490 pounds per square inch in cast iron and 2,100 pounds per square inch in the steel bolts. It is hardly possible for a machine driven by an alternating-current motor to run much over its rated speed, but even at 41 per cent. higher speed, which would double the stresses, the wheel would still be absolutely safe.

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*Chief Engineer, Canadian Rand Company, Ltd.

VARYING AMOUNT OF AIR COMPRESSED.

Attention is called particularly to the method of unloading the air cylinders, so that the amount of air compressed will be varied to suit the requirements.

The inlet valves on both high-pressure and low-pressure cylinders are of the Corliss type with releasing gear but without dash pots, as shown in Fig. 2. When the piston is compressing air the valve does not release, but is opened by the eccentric a little after the beginning of the suction stroke (about 3 per cent., to allow for the expansion of the air in the clearance space), and closed by the eccentric at the end of the stroke. The action of the unloader is to admit air to the trip cylinder, shown in section, which pushes out the plunger, pushes down the trip cam, and releases the hook. The valve then remains open and the air blows freely in and out of the cylinder. The valve is prevented from moving too far when released by a stop on the outer valve bonnet. There are eight Corliss valves, and these are unloaded in pairs in the following order:

1st stage. Left-hand low-pressure front valve and left-hand high-pressure rear valve.

2d stage. Right-hand low-pressure front valve and right-hand high pressure rear valve.

3d stage. Left-hand low-pressure rear valve and left-hand high pressure front valve.

4th stage. Right-hand low-pressure rear valve and right-hand high-pressure front valve.

The diagram, Fig. 3, will make it plainer.

The first stage unloads 1, 1, the second stage 2, 2, the third stage 3, 3, and the fourth stage 4, 4. This gives the following variations of capacity: Full load, ¾ load, ½ load, ¼ load, no load. At whichever stage the machine is working the cylinder ratio is the same, and whatever air is being delivered is being compressed at full compound efficiency.

There are small weights inside the large weights arranged to be picked up or dropped one at a time, at each stage, so that not more than a quarter of the load will be thrown off or on at one time. Throwing on one-quarter of the load at a time does not produce any perceptible rush of current in an A. C. motor, while a large compressor in which the whole load is thrown on and off suddenly is apt to produce surges in the line. An advantage of this method of unloading is that at the same time that it reduces the power it also reduces the pressure on the journals; when the capacity is reduced to one-half, the load on the bearings is also reduced to one-half, and when there is no load on the cylinders there is no working load on the bearings.

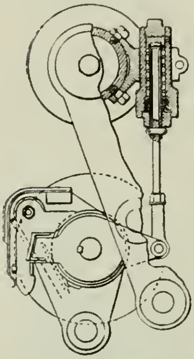


FIG. II. RELEASING GEAR.

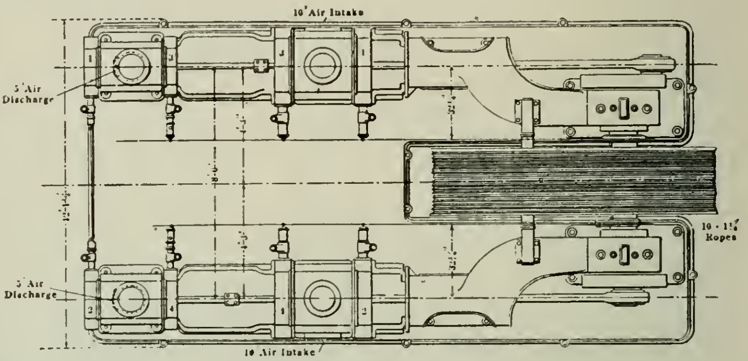


FIG. III. PLAN, SHOWING CUT-OUTS.

A summary of the good points of the duplex tandem compressor with four-stage unloader is as follows:

1. High efficiency of compression due to maintaining constant intercooler pressure and proper cylinder ratio.

2. Load is thrown on and off gradually, producing no disturbance in electric lines.
3. Reduces load on journals at part loads.
4. Delivers cooler air, thus also saving power.
5. Maximum demand for current varies approximately with the requirements for air.

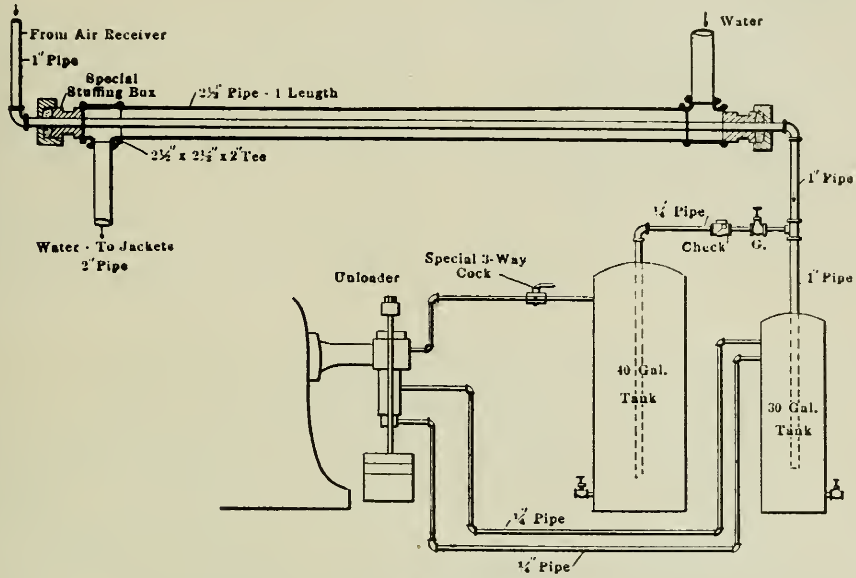


FIG. IV. FOUR-STAGE UNLOADER AIR SUPPLY.

AIR SUPPLY TO UNLOADER.

In order that the unloader may remain sensitive it is desirable that the air supplied to it should be clean, cool and dry. Fig. 4 shows an arrangement for this purpose and also a starting device. The air supply is taken from the main receiver (not shown) and passes through a length of water-jacketed pipe to cool it and condense the moisture. The moisture and any scale will collect in the 30-gallon tank shown. From the 30-gallon tank two pipes lead to the unloader, one to the bottom and one to the middle. The pipe to the bottom of the unloader raises the weights, while the pipe to the middle supplies the air which operates the trip cylinders. If these two pipes were combined in one, then the unloader would "hunt" or "dance" on account of the drop in pressure in the small pipe, caused by air being drawn off to operate the trip cylinders.

STARTING DEVICE.

The 40-gallon tank is intended to hold air over noon or night so that the machine may be unloaded before starting. By turning the three-way cock, air is admitted by the upper pipe to the exhaust ports of the unloader and from there to the trip cylinders, and releases all the Corliss valves so that they remain open and the machine starts up without load.

PRACTICAL COMPRESSED AIR REFRIGERATION

Discussing the practicability of a public refrigerating service with pipe-line distribution, Mr. Jos. H. Hart, in the *Engineering Magazine* speaks as follows of the possibilities of compressed air for the purpose:

Cold-air refrigeration by utilizing balanced expansion and obtaining cold air by the performance of work is not an efficient refrigerating process. It is used, however, to a very great extent in England, even in large units, and has been reasonably satisfactory. It is also used on shipboard and is in use in some special refrigeration systems in transportation for the conveyance of perishable products. Thus the method while not as efficient in individual units as a corresponding ammonia system, still is not so inadequate that it cannot compete under special local conditions. A compressed-air plant produces refrigeration when the air is used to do work, and in many cases the exhaust from an air-driven engine will clog up with ice formed from the moisture present in the atmosphere. The compressed-air plant of Norwich, Conn., which supplies compressed air produced by a hydraulic air compressor to the entire town through a system of mains, has recently developed a machine for the production of liquid air from the exhaust of the average air-driven engine. Such a refrigerating system for pipe-line service would consist simply of a single line of pipe supplying compressed air at normal temperature. A small machine utilizing this air for work in the production of electric light for the dwelling or building could then turn its exhaust into a refrigerating chamber, and after that could allow it to escape into the atmosphere. Thus, such a system constructed on the above lines would be simplicity itself as far as the details of pipe-line construction and operation were concerned. The air pressure need not be great for mild refrigeration, and its advent is probably dependent only upon the development of a more efficient and satisfactory air compressor than the modern reciprocating type. The rotary air compressor will probably find a new field waiting as soon as it becomes an efficient practical machine.

VENTILATING THE GLUE ROOM

When hot weather comes, the disagreeable features of the glue room become more emphatic, and especially is there need for fresh air. At the same time it is just as imperative to keep drafts out of the glue room in summer as in winter. It won't chill the glue as quickly as cold winter drafts, but the trouble is, a current of air passing over an exposed surface that has been spread with glue, evaporates the surface moisture of the glue and forms a sort of a skim on it, so that it doesn't adhere well to the wood when put together. In summer it is not so much a question of temperature; in fact, the temperature is nearly enough right that little regard need be given this feature, but care must be exercised against currents of air passing over glue when it is freshly spread. Sometimes, when the gluing is not going on steadily, one can open up windows and doors until the air blows through freely for a while, and thus get some fresh air, and then the room may again be closed sufficiently to prevent currents of air when gluing begins again. This is not practical, however, where gluing is going on steadily, and it therefore becomes important to seek some means of ventilating for the comfort of those working in the glue room, that will not involve currents of air that do harm to the work.

Fortunately, we have made lots of progress along the line of ventilation, and there are various mechanical appliances offered for producing ventilation or a change of air in rooms every few minutes, without causing drafts. Ventilation of this kind has become quite a feature in the better class of hotels and public rooms of various kinds, and some of this idea in a modified form may be worked into the average glue room by a little attention to the subject. The main theory to work on is that of exhausting the air rather than blowing or permitting fresh air to blow in. Sometimes it can be done by ventilators at or near the top of the room; at other times it may call for light power-driven appliances. It is not sufficient to have vents open about the top of the room so that there is a current of air circulating through the top and no current through the bottom part of the room, because this doesn't in any great measure refresh those at work. What is wanted is a continual change of air in the work room—that is, throughout the room. This should be gotten, however, without producing currents, at least currents of such velocity as would rapidly evaporate the moisture from the surface of glued stock.—*Woodworker.*

A NOVEL TIMBER TESTING MACHINE

How is the strength of wood affected by repeated shocks? At the present time no satisfactory answer can be given. To fill the need for information on this important subject a special form of impact machine has been designed by the United States Forest Service to investigate the behavior of wood under repetitive loading. It is to be built at Seattle by the University of Washington, and is to form a part of the forest service timber testing station operated in co-operation with the university.

This machine will be provided with a 1,500 pound hammer which can be dropped upon the wood specimens under test from any height up to 3 feet. It is so constructed as to be both automatic and autographic. The record showing the behavior of the specimen under test is drawn on a long strip of paper which constantly unwinds from one cylinder and rolls up on another. This record is drawn by means of a pencil attached to the hammer of the machine. When the machine is started the hammer is automatically raised to a height previously determined, when it falls on the specimen, and continues to be automatically raised and dropped until the machine is stopped.

From the results to be obtained from the tests made with this machine the forest service hopes to be able to devise more accurate and reliable methods for calculating the stresses which timbers used in bridges and other structures subject to repetitive loading have to stand.

[For operating the hammer, especially on account of the occasional and intermittent character of the work, of course compressed air should be used. Ed. *C. A.*]

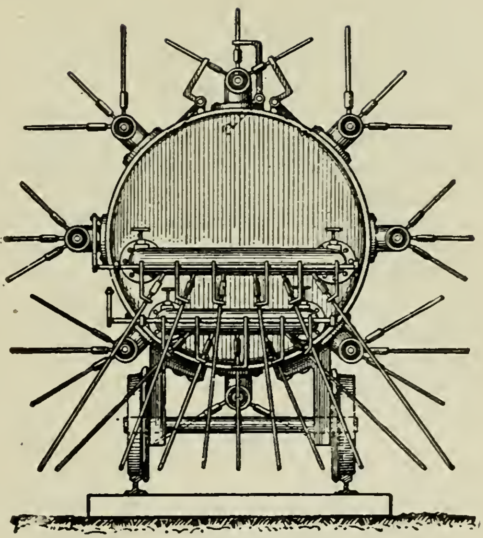


FIG. 2

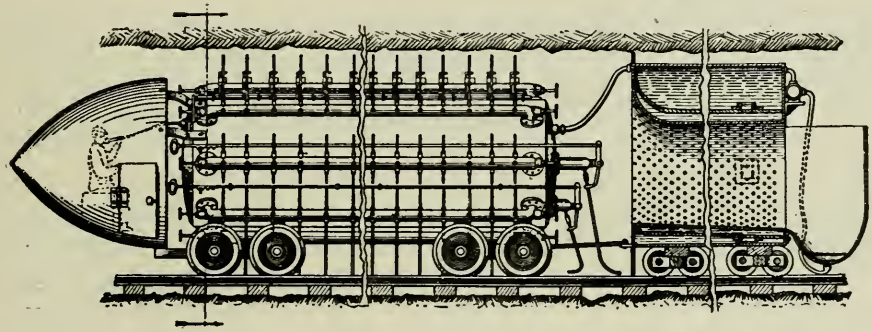


FIG. 1.

A SPRAYING AND DUST LAYING DEVICE FOR COAL MINES

The following we condense from a paper by William Clifford in *Mines and Minerals*:

The researches of Sir Charles Lyell, Mr. Faraday, Mr. William Galloway, Sir Frederick Abel, and others led to the appointment of a Royal Commission to investigate the dust problem in England, and to the promulgation of the well-ascertained fact that the presence in the atmosphere of a mine of a quantity of firedamp too small to be detected by an ordinary safety lamp, by the addition of dust become explosive. There have been many accidents where the loss of life would have been small, if only firedamp had been ignited, but where dust acting like a train of gunpowder carried death and destruction into every corner of the workings—far beyond the reach of the flame which the initial local explosion of firedamp produced.

Many remedies have been suggested. The watering of the dust at points where blasting is done, and of main roads also was one remedial measure recommended and carried into practice. The watering of lengths of road so as to divide a mine into districts, each separated by a wetted zone, the lining of long lengths of road with smoothly plastered concrete and sweeping the same clear every day in order to attain the same isolation as was sought by watered lengths has been advocated by eminent engineers in their evidence before a British Royal Commission on Mining. In the North of England coal field the tiresome and laborious practice of brushing the dust from the walls of roads by hand, and filling the same into cars (tubs) now prevails to some extent, so serious a menace to safety is considered the presence of this dust in a mine.

To do away with this dust difficulty the writer has devised a system and an apparatus to remove this dust from the points of deposition and to transport it by means of the ventilating current to points convenient for filling out, when accumulated in quantities beyond the carrying power of the air.

The general plan of operation is as follows:

(1) The diverting of the main ventilating current of a mine temporarily for the purpose of operating this dust-removal system and apparatus to a single district or road, by means of doors as shown in Figs. 3 and 4.

(2) The reversing of the air-current if need be.

(3) The fixing of permanent water-jacket tanks at points near the outlet of the mine, as seen in bypass roads in Figs. 3 and 4.

(4) The deflecting of air from the central part of the road operated upon, to the sides, roof, and floor, thus greatly increasing its velocity, and hence its capacity to carry solid matter.

(5) The detachment of dust by means ot jets of air striking the walls of mine, on every portion of their surfaces, and the carrying the detached dust forward, by the locally increased velocity of current, which the restriction of area of flow, by deflection to perimeter of roadway operated upon produces.

Fig. 1 shows a side view and Fig. 2 a front elevation of the machine which consists of a tank in which compressed air is stored. By means of the adjustable pipes shown, the air escaping from the tank may be directed in any desired direction so as to dislodge the dust. This dust is then carried through the orifice in the front part of the machine by the air and as the dust-laden air passes through this orifice it is sprayed by water forced out of the surrounding water-jacket by compressed air which is conveyed to the water-jacket from the air tank by a pipe as shown in Fig. 1. A considerable amount of the wetted dust will be entrapped in the hopper in the end of the machine.

The method of operating the machine is shown in Fig. 3 which represents a pair of headings forming the main passageway of the mine. The fan is working as an exhaust fan and the air travels in the direction shown by arrows. The machine is in the intake road, and it is assumed that it has traveled along the road driving the dust before it, and such dust as is not quenched in the water-jacket, is passing through the cross-cut shown immediately in front of the machine, into the return. A door with a regulator in it is closed across the main road in front of the machine. The regulator allows a small quantity of air to pass forward into the mine beyond, and return through a corresponding regulator in the return. A coarse wetted cloth covers the regulator in the intake. In the return airway near the fan is a bypass road with door to divert the air-current from the straight road through one of the fixed annular water-jackets with perforations in the interior wall. This annular jacket is fed from a regular source of supply under pressure, and the effluent water is carried away by the ordinary drains of the mine.

Fig. 4 represents the same things except that it is assumed that a panel only has been operated on in Fig. 3, and that this panel is now cut off by the closed door in front of the ma-

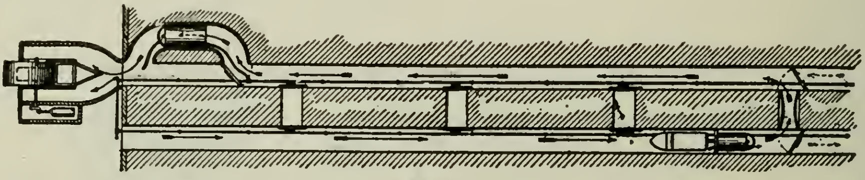


FIG. 3

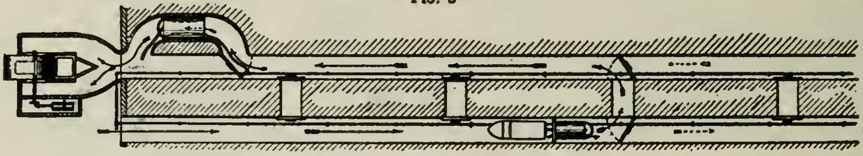


FIG. 4

chine in Fig. 4, and the air passed into the return by another cut-through. In cases were the accumulated load of dust is too great for the velocity of air-current at command, the work is done in detail, panel by panel, or the machine run over the ground a second time.

This process is repeated until the whole of the lower road or intake has been swept clean. The machine is now usually detached from its water-jacket, taken into the return and a clean sweep is made from the point shown by the closed door in Fig. 3, to the mouth of the bypass road and its fixed water-jacket.

By thus using the apparatus alternately on the intake and on the return, the accumulated dust is driven through the water-jacket in the bypass road near the fan. As the pipes from the compressed-air apparatus are flexible they may be deflected forward so that the current from them will strike the upper part of the coal face. The long pipes near the floor can be raised so as to direct the currents against the coal face and the neighboring roof, while the bent pipes shown in Fig. 1 may be used to blow the dust from an undercutting.

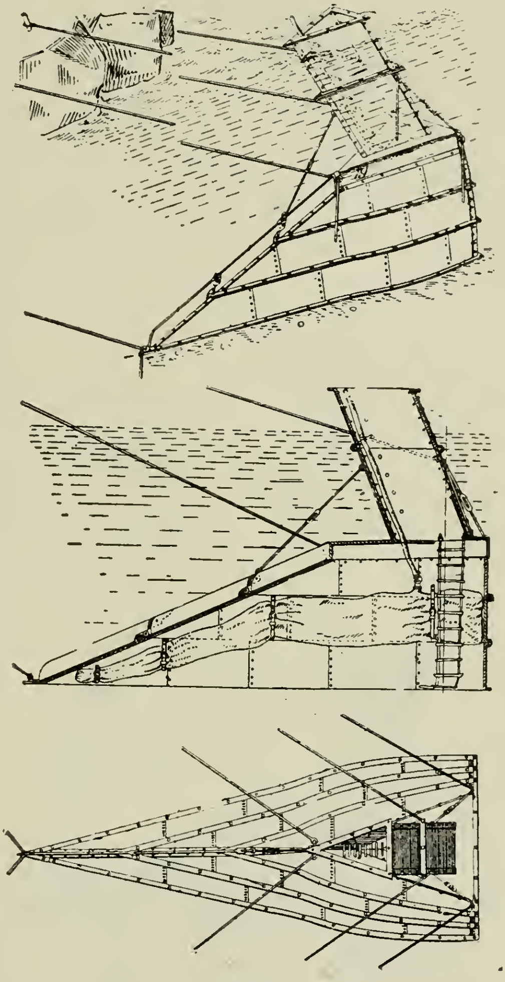
The use of this apparatus assumes a vigorous ventilating current or reserve power in the ventilation to produce it. In order to make the arrangement effective in new mines the main airways, both intake and return, should be such that the whole ventilating current can be passed through a single road or district.

CABBAGE—BEFORE AND AFTFR

When the United States consul at Marseilles wrote to the mayor of the city for permission to make investigations with regard to the disposal of garbage, sewage and other city waste, for his government, he was answered in this wise:

"Garbage is one of the finest dishes of the place. Well cooked and nicely prepared, as they do it in the country, it is something exquisite."

As an example of Gallicizing of the "American" language, this is a gem. As a hint to American sanitary officers, it is more. It is sublime. With its new garbage reduction plant and its splendid new sewers, St. Louis bids fair to soon dispose of its offensive refuse so effectively that the people of the city will be like the mayor of Marseilles, unable to distinguish between the thing, garbage, and another thing the name of which it resembles, cabbage, and in another quarter of a century may make the same reply if asked the same question.



MOVABLE CAISSON FOR RIVER MINING

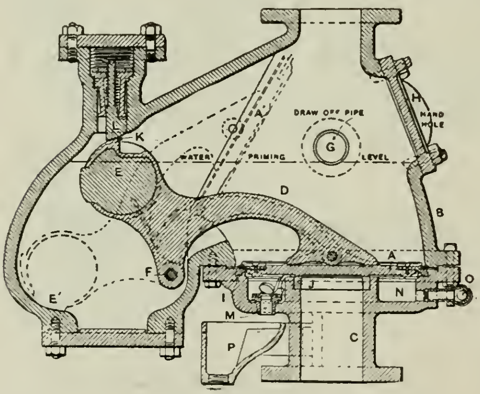
The recently patented device shown in the cut is to be used in rivers where the sand or gravel is rich in precious metal and where the flow of the water is so swift that it is impossible otherwise for workmen to hold their footing and work the pockets. The caisson is quickly movable from place to place and is held in place laterally by the guys shown, the water rising in the caisson to the same height as outside and the men working in the water with or without divers' suits according to the depth.

The caisson is made up of sections bolted together according to the height or capacity required, the point of the caisson facing the current the tendency of which is to make the structure hug the bottom more securely. An open tube or shaft is provided for workmen to enter, the top of sufficient height to be always above the water.

There is an air tight bag located within the caisson with a hose by which air under suitable pressure may be admitted and when this bag is distended to approximately fill the caisson the latter becomes buoyant and may then be floated to another working position. The bag when collapsed may be folded into a small compass and held by straps against the side of the caisson and out of the way.

THE ROCKWOOD DRY-PIPE VALVE

Automatic sprinkling systems for fire protection, which began with those in which the pipes were kept constantly filled with water, were subject to the generally fatal objection that the water would freeze in the pipes and the pipes would burst or would not be operative when the emergency occurred, and so dry-pipe systems take their place. The valve here shown in section, the invention of Mr. Geo. I. Rockwood, Worcester, Mass., and approved by the Underwriters' Laboratories, is an essential feature of such a system.



RCOKWOOD DRY-P PF VALVE.

Besides the water supply with sufficient head an air pressure also is maintained to keep the system operative. The normal position of the moving parts is as shown in the cuts. Air under the required pressure constantly fills the large chamber, acting against the water pressure on the under surface of the main order. When the air pressure acting on the surface of the primary water is relieved by the opening of a sprinkler, the upward pressure of the water causes the valve plate to lift and an intermediate chamber fills with water, with the result that the entire force of the water exerted over the full area of the plate pushes it over to the wide open position and thus leaves a straight, unobstructed passage for the water to the system.

The lower part *C* of the valve body carries the air and water seats. The bronze valve plate *A* acts both to close the water inlet *J*, and to seal the air valve chamber by the contact of the rubber ring at its periphey with a black-tin air valve seat *I*. The valve plate and a counterweight *E* are attached to the swinging arm *D*, the whole swinging about the axis *F* as the valve opens to the position shown by the dotted lines. In the opening or closing of the valve the center of gravity is so changed that the valve will remain in either position.

The relative pressures of the air and the water must be maintained at a certain relation to each other within easily practical limits. With 50 lb. water pressure the limits of the air pressure are 15 and 25 lb.; at 75 lb. water pressure, 20 and 30 lb.; at 100 lb. water pressure, 25 and 35 lb., and so on.

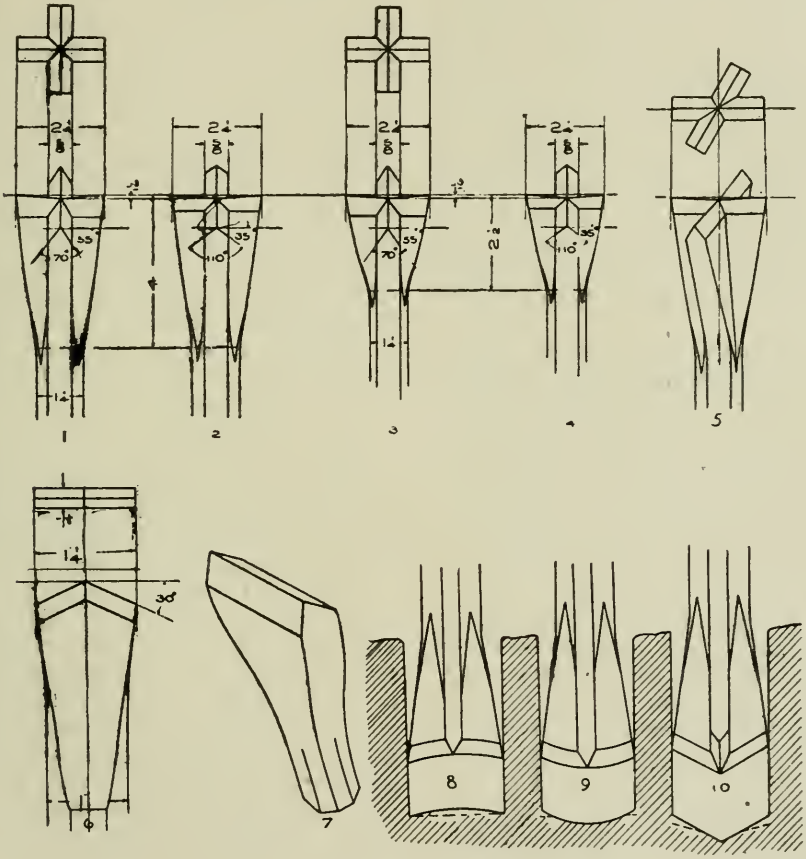
As a means of precaution the projection *K* on the counterweight is adopted to engage a spring catch *L* when the valve opens. This will prevent the valve plate returning to its seat if the combination occurs of a feeble water supply, a corroded or jammed spindle *F* and a reversal of flow after the riser has filled with water. The ball seated swing chick valve *M* is automatically held from its seat by the contact of its arm extension with the under side of the valve plate, and thus allows any water which may leak by *J* to run freely out of the intermediate chamber *N* into a drip cup outside. A drain valve for emptying the entire system of sprinklers is piped at *G*, and at *O* is a drip pipe for drawing the priming water left in the valve body when the system has been emptied.

After October 1 a letter weighing one ounce can be sent from any part of the United States to any part of Great Britain and Ireland, or vice versa, for two cents.

SHAPING, MAKING AND USING ROCK DRILL BITS

By D. J. O'Rourke.

The question of drill steel, its selection, care and use, is one which is given far too little attention, while in many cases it is the determining factor as to the economic success of a drilling plant. If the steels are of good material, carefully made, sharpened and tempered for the work to be done, and if fresh steels are put into use as soon as the gage begins to wear, the drills will come up to expectations as to speed and efficiency; but if the blacksmith is incompetent and the drill runner careless, the management could better afford to throw out its machines and go back to hand drilling.



ROCK DRILL BITS.

THE BLACKSMITH.

The blacksmith's work should be recognized as almost equal in importance to that of the master mechanic at a drilling plant. The best smith is none too good, even if there should not be enough work to justify the wages he may demand. It is cheaper to have a blacksmith and helper idle once in a while than to have two or three drill runners and their helpers standing around watching the drills wearing themselves to pieces, and perhaps helping them along with a sledge, while the drills fail to give results, merely because the bits are not right. There are also other men on the premises shoveling away dollars in the shape of coal, and all summed up, the idle time of the blacksmith and helper is an insignificant item.

When a new compressor plant is installed, every feature whereby a pound of coal or an extra foot of air may be saved or made is investigated, and every precaution is taken to secure economical results. After the plant is running, the drilling is sometimes allowed to run along in such a way that anywhere from 10 to 50 per cent. of the power developed is lost. No one would think of allowing a hoisting engine to hoist a load with the brakes partially set, but something similar occurs when a rock-drill bit is run so long that it is the same gage for an inch or more back of its cutting edge, or is allowed to be made with shoulders on it in the first place.

SHAPE OF THE BIT.

For drilling rock of any kind, the cross-bit made like Figs. 1, 2, 3 and 4, sometimes modified to the X shape shown in Fig. 5, is usually employed. It will be observed that the bits above referred to are made concave, with the corners of the wings ahead of the center. This design is recommended because used bits show very little wear at the center as compared with their outer edges. This indicates that the corners do the largest part of the work. The cutting done by them so weakens the rock toward the center of the hole that it does not afford so much resistance to the center of the bit.

Figures 8, 9, and 10 show what actually takes place in fracturing the rock with bits of several shapes. Figure 8 shows the concave bit, whose corners cut ahead of the center, making the line of breakage very weak and leaving little resistance for the center of the bit, as described above. Figure 9 illustrates a convex bit. In this, the center has to cut ahead of the corners. The fracture line is thus divided, leaving but little work for the corners to do. The cross shape of the center, together with the increased amount of work which falls upon it, in this case, greatly retards its cutting efficiency. Figure 10, the diamond-pointed bit, also divides the fracture line, but at the same time increases its length, leaving less cutting for the center. With this bit, the rock tends to break to a flatter angle than the angle of the bit, allowing the center to go in advance of the corners for a few blows, when the entire bit again comes in contact with the rock, fracture again takes place, and the process described above is repeated. This bit is recommended only for marble, soft limestone, and other even, soft rocks. Its advantage for this work lies in the fact that nearly all drilling in quarries is done on laid-out lines, so that this form enables the holes to be started accurately. The bit, however, is made very thin and is not strong enough to be satisfactory on general mining and contract work. The flat, or "bull" bit, as it is sometimes called, shown by Fig. 7, is made in various shapes, but no matter how it is made its use is very severe on a rock drill. If thin, it has no reaming qualities; if made heavy, as it generally is, the blow delivered imparts a severe jar to the machine. The flat bit, with diamond point, Fig. 6, is a style which has been used in marble quarries from the earliest introduction of the rock drill. The steam pressure used in those days was considerably lower than now, so that this bit was satisfactory, and cut slow enough to ream the holes fairly well. Even under these conditions it was hard on the rotating device, but when higher pressures were introduced its cutting capacity was increased, while its reaming qualities remained the same. The flat bit may cut more rapidly for a short time, but in the long run the cross will be found more economical. The use of the X bit, Fig. 5, is not general, but sometimes is desirable when a cross-bit will persist in drilling "rifled" or five-fluted holes on rock of some kinds. Sometimes rifling is charged to the machine, but the fact that the X bit is not required on all kinds of rock rather disproves this imputation.

SHARPENING THE BITS.

Figures 1 and 2 are bits for hard, non-gritty rock, and are alike except for the different angles shown on the cutting edges. Figure 1 shows about the highest angle to which the cutting edge can be made without danger of breaking. The angle shown on the cutting edge in Fig. 2 is one of many which may be used under different conditions, without any change in the bit. In cutting hard and medium hard rock, sharp drills and a wide-open throttle may be used to good advantage, and the hole will not ordinarily clog with mud, as the amount of rock loosened by each blow is so little that it is at once mixed into slush by the water in the hole. The sharp rebound of the drill when striking hard rock, together with the positive recovery of the machine, quickly gets rid of this slush. If the same bits and drill are run on an open throttle in soft or even medium soft ground, the hole soon becomes clogged. The reason for this is that while the hole remains of the same diameter, and the amount of water for mudding purposes is therefore the same, the steel chips out three or four times as much dust at each blow as it does in hard rock. The rate of cutting should therefore be reduced in order to keep the drill working at maximum efficiency. The speed may be regulated by throttling the air or steam but this reduces the rapidity of action of the drill, so that it does not always mix into slush the dust caused at even the slower speed. The recoil of the steel from soft rock is also considerably less. In soft rock duller bits should be used, like that shown in Fig. 4. The angle of the cutting edge may be even higher than this, sometimes almost square on the end, in order to secure good results.

LENGTH OF UPSET.

In connection with the above subject, it is well to bear in mind the length of the wings or ribs for different kinds of work. Figures 1 and 2 show an extreme length for very hard rock, intended to give strength and hold the gage as long as necessary. Figures 3 and 4 show shorter ribs which give the bit more clearance and make it more desirable for general purposes. Under ordinary conditions its ability to mix mud is much greater than that of the long bit like Fig. 1. This shortness gives greater flare to the wings, causing a greater backward thrust to be given the cuttings, whether wet or dry. In rock which wears the gage rapidly, however, the upset should be longer. For drilling dry holes in tunnel headings or elsewhere the bit with short ribs has less tendency to allow the hole to draw up. The friction of this style of bit retards the machine but little, and will cause it to cut down toward the lower side of the hole, thereby straightening it. If this is done in time, it saves frequent drops of the arm and keeps the hole where it is wanted. It will be found on experiment that such results cannot be gotten if a long bit with very slight clearance is used. The wings are five-eighths of an inch thick for the size shown in Figs. 1 to 4, and should never be less than that for this size of bit and steel. They should be the same thickness throughout to allow free return of the cuttings. If gage less than two and one-quarter inches is desired, make the bit correspondingly shorter.

GAGE.

It should be especially noted that in all the sketches the outer edges of the wings are square and not rounded to the circle. This feature is very important, to preserve the gage of the hole. Whether the bits are sharpened by machine or by hand, care should be taken that no bits are made with the outside edges made rounding. The question of maintaining the gage of the hole throughout its length is very important. It should be carefully determined just how much work each drill bit will do before the gage begins to wear. In the hardest rocks a bit is never in condition to use the second time, and from 24 ins. to 30 ins., depending on the length of the feed, is all that is ever attempted. Sufficient steel is therefore supplied, so that a sharp set is on hand for each hole. In softer rock and ore it frequently happens that the steel will not become dull even if used on several holes. Drill runners are, therefore, apt to disregard the question of the gage so long as the cutting edge is sharp. The gage, however, causes the rub in more than one sense. This is where the rub comes in that retards the work of the drills, shortens their life, consumes power, and increases the repair bills. For example, on this kind of rock a runner is given two sets of sharp steel to drill a required depth. Each set will drill perhaps two holes without making trouble. About the third hole on which this steel is used the bits stick and there is a constant demand for a hammer or a chuck wrench with which to beat the steel, and if the right point of humor is reached there is no discrimination shown between the steel and the drill piston. Here is a drill that worked all right on the first hole, fairly well on the second, and will not work at all on the third. The rock is the same and the drill is the same, but not so the bits. The only sharp bit that can be gotten into that hole must be made specially in the blacksmith shop half a mile away, so the hammering is kept up and the drill finally worked down somehow, taking usually more time than it took to put in the first two.

When the gage wears so that a new steel is needed in order to insure its following the last, an entirely new set should be used. It makes no difference if one of the bits still appears good, for it is economical not to waste time with it. On any rock on which the cutting edges are not dulled upon the first hole, a system should be devised by the foreman or superintendent to determine how much each bit will do without too much "hammer help." The improvement will be very pronounced.

The runner or blacksmith should have nothing to say as to this system. The blacksmith should have rigid instructions to furnish all bits to the exact gage required, so that the new bits will work freely when placed in the hole. Much time is wasted from the fact that bits are not made exactly to gage to begin with.

Users of mechanical drill sharpeners are advised to give thought and care to securing the proper dies and dollies to make bits suitable to the conditions under which they are to be used; also that when drills are being dollied the dies do not open. Some rather impossible-looking bits are occasionally seen for this cause alone.

TEMPER.

The matter of tempering bits is another point in which the blacksmith can save or waste much drilling time to his employers. A competent blacksmith will furnish bits of the precise temper, to suit the rock being drilled. —From *Mine and Quarry,* slightly condensed.

MODERN DEVELOPEMENT OF BLOW-PIPE PROCESSES

Blow-pipes may be classed according to the combustible material which they employ—hydrogen, acetylene, ordinary gas, and naphtha. All these utilize the same supporter of combustion, oxygen, which is usually supplied in flasks or tanks compressed to 150 atmospheres. It may be obtained by the electrolysis of water, by the distillation of liquid air, or by chemical reactions. The earlier forms of blow-pipe were operated with hydrogen obtained by electrolysis of water and stored in receptacles if prepared in advance, or in other cases generated at the point of use. Acetylene, employed in the second type, is obtained by the action of water upon calcium-carbide, and also may be generated in place or stored under pressure by taking advantage of its solution in acetone. It is not practicable to compress acetylene in reservoirs as may be done with hydrogen, because of its explosive qualities when compressed. MM. Claude and Hesse devised the acetone-solution method. The solution is stored in a flask filled with porous material, which forms a capillary tubular structure and prevents the spread of explosion.

The great advantage of blow-pipe brazing is that it is quite as applicable to mild steel as to iron, and that it permits the brazing of thin steel plates which were heretofore riveted or clinched together. The blow-pipe is further most valuable for use wherever it is necessary to work upon parts already in place. It comes into play particularly in the manufacture of metal tanks, various vessels made of enamel ware, feed-water heaters, etc., permitting the manufacture of forms of apparatus requiring numerous and complicated joints impossible to manufacture by forging. It has the further advantage of being a light apparatus, easily manipulated and requiring no elaborate installation.

At first sight it might appear that the melted or cast metal produced would not have the qualities of strength, and particularly of elasticity, shown by rolled or hammered material. Surprising results, however, are secured when care is taken during the process to avoid overheating or oxidation of the metal, or its alteration by the introduction of impurities such as sulphur or phosphorus. If, for example, we braze thin sheets or tubes of a few millimetres thickness and subject the brazed part to a light hammering or even a mild tempering, the metal will be found perfectly ductile and the joint will exhibit a strength almost equal to the resistance of the original metal. Tubes thus welded may be crushed or twisted, and plates may be bent and refolded, following the weld, without showing any cracks.

When it comes to the brazing of comparatively thick plates such as those of a boiler, the problem is more complicated because of the greater difficulty of producing uniform, thorough fusion to a thickness exceeding 6 or 8 millimetres. Under such conditions use is often made of an artifice which should be condemned, and which has to some extent discredited autogenous soldering of heavy plates. This artifice consists in chamfering both edges which are to be joined, and filling the space thus left by melting an iron wire in the blow-pipe flame. The procedure is not absolutely bad if it is very skilfully carried out, if the operator is careful to use a flame heating a large area and to let the drop of melted metal fall only on the part of the joint which has already been raised to the fusion temperature. It is easy to see what extreme attention is necessary to succeed in manipulation of this kind; if it is ill done, we get only poor adhesion; if it is well done, the relatively large quantity of melted metal introduced between the two edges lowers the strength and destroys the ductility. Test pieces submitted to tension break without elongation.

A process of autogenous soldering which is employed with much success and which is particularly applicable to plates from 6 to 25 millimetres thick is the following:

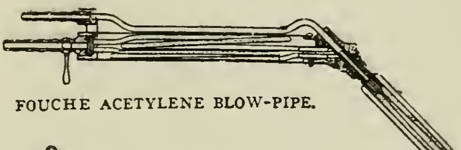
The two pieces to be joined are brought edge to edge without superposition, in perfect contact; if necessary to secure this they are first subjected to a light cut on the planer; they are then heated by means of two blow pipes, one above and one below, exactly opposite to one another, and producing as large a heated zone as possible. When fusion begins to appear on the surface it is safe to conclude that the interior of the sheet is at a white welding heat. The blow-pipes are then withdrawn and by a simple mechanical arrangement they are replaced by an anvil and a very light hammer not exceeding one or two kilogrammes weight. The blow of this hammer is sufficient to cause a consolidation of the metal along the two butting edges.

Perfect welding is secured and it is probable that the light hammering produces at the same time a certain orientation of the molecules favorable to the elastic properties of the metal In fact, if test pieces of metal so welded are tested under tension to the breaking point it is found that the grain of the fracture is not that characteristic of cast specimens, but is perfectly homogeneous, and like that of the original plate. The strength is but a small percentage less than the original and the elongation is satisfactory. Metal of a tensile strength of 36 to 38 kilogrammes and elongation of 25 to 28 per cent. shows after welding a tensile strength of 36 kilogrammes and elongation of 13 per cent. These results are completely satisfactory for the majority of cases in which it is desirable to substitute for riveting a process of soldering, secured rapidly and by simple appliances requiring no complicated or costly installation.

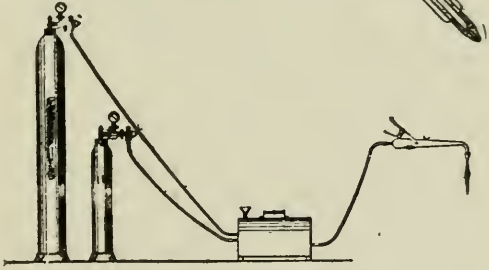
In all ordinary forms of blow-pipe there is of course one tube supplying combustible gas and another supplying the agent of combustion. The differences consist principally in the arrangement of these tubes and especially in their mode of connection. All present forms make use, under conditions which we shall examine further, of a mixture of gases effected in advance.

ACETYLENE BLOW-PIPE.

At first an ordinary form of blow-pipe was used for burning acetylene with oxygen. The two gases were kept separate up to the tip of the blow-pipe; that is to say, to the actual point of combustion. With acetylene, however, a serious inconvenience appeared; a heavy deposit of carbon took place, the flame was suppressed and indeed a sort of carbon mushroom resulted. It was therefore necessary to resort to some form of blow-pipe in which the mixture of gases might be made in the interior of the apparatus. But with acetylene a serious accident was to be feared, as the flame might flash back into the blow-pipe and cause an explosion. It is known, of course, that to prevent a back-draft of the flame the issuing gas must ordinarily have a velocity higher than that of the explosion wave, which for a mixture of oxygen and acetylene is extremely high. Practical experience showed that it was not necessary to attain this point because of the very small section of the blow-pipe tip. A velocity of flow equal to 150 metres a second is sufficient to prevent the flame from traveling back into the apparatus. In further prevention of this return of the flame the interior was filled with porus material, but this made it necessary to increase the pressure to the equivalent of 3 to 4 metres of water.



FOUCHE ACETYLENE BLOW-PIPE.



OXY-HYDROGEN BLOW-PIPE WITH MIXER.

A problem still to be solved was that of utilizing acetylene not under pressure—that is, gas produced immediately in the works in calcium-carbide apparatus. M. Fouché found a very interesting solution by introducing the oxygen into the apparatus through an injector, which draws a flow of acetylene with it. The acetylene enters through extremely small tubes which do not permit the passage of flame.

OXY-HYDROGEN BLOW-PIPE.

In this apparatus the two gases are always used under a pressure. The original form of hydrogen blow-pipe consists simply of a brazed sheet-steel receptacle terminating in a neck, upon which the blow-pipe tip is screwed. To the other end are brazed two attachments for the rubber tubing through which the gas flows from the reservoirs. Economy of combustion has been sought by preheating the gases. For this purpose they are made to pass through a coil surrounding the flame. This gives the regenerative blow-pipe. Lastly, in some important installations use has been made of a mixing blow-pipe. In this the blow-pipe itself is of the type already described, but it has a single attachment, for in this case the gases are mixed in advance.

It should be added that apparatus employing acetylene in solution and hydrogen in tanks is best suited for use in work requiring a portable installation and in establishments where continuous use of the process is not required; while it is more economical to use an installation with generators for acetylene and hydrogen where the work is to be continuous, or where the applications are many enough to allow continuous operation of the generating apparatus and are performed upon parts so light or so easily handled that they can readily be brought to the blow-pipe.

THE CUTTING OF METALS.

It is well-known that iron burns easily and rapidly in an atmosphere of oxygen gas. The experiment is familiar in every course in physics and chemistry. The same phenomenon occurs when a jet of oxygen is directed upon iron heated to a bright red—that is to say, the metal burns and the heat evolved fuses the oxide. The process for cutting plates by oxygen is based on these phenomena; it can readily be seen that it is possible to divide a piece of metal by means of an oxygen jet, but it is not easy in practice to attain a regular and clean cut.

At first use was made of an oxy-hydrogen blow-pipe to bring a certain portion of the work to a bright red heat. Then the flow of hydrogen was cut off and the current of pure oxygen was increased. A good combustion was produced, but it did not proceed very long. The resultant iron oxide not being hot enough, lacked fluidity; it was with difficulty removed, became mixed with the partially melted iron, and thus obstructed the close contact of the metal with the oxygen; the combustion stopped and it was necessary to bring the blow-pipe into play again. The manipulator, even after long practice, could obtain only an irregular cut, dirty, and with edges incrusted with closely-adhering oxide.

One of the engineers of a company in Brussels therefore devised a double apparatus which entirely remedies thes difficulties. This consists of two blow-pipes in one piece, which travel along the section to be cut. The first is an ordinary oxy-hydrogen blow-pipe which heats the metal to a bright red; the second directs a fine jet of pure oxygen upon the heated spot under a pressure varying with the thickness of the metal. The action of the two blow-pipes is continuous; the first prepares the way for the second. furnishing a volume of heat sufficient to permit instantaneous combination of the oxygen with the metal in the heated zone. The metal is not melted, and the adjoining parts remain unaltered, as the action proceeds too rapidly for the heat to spread into the mass and the oxidized portion is removed by the pressure of the oxygen; the section is cleaner than a saw-cut and its width never exceeds 4 millimetres 1-16 in. The speed of travel of the double blow-pipe is about 20 centimetres (8 in.) a minute; in other words, the operation is quite rapid and comparable to hot sawing. The consumption of gas is relatively small, depending upon the thickness of the piece to be cut, and as the work is rapidly done the labor cost is not important.

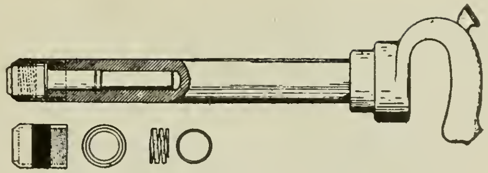
The double blow-pipe, which is easily handled and furthermore may be guided by any sort of mechanical device, is available for cutting not only thick plates, but also, and with equal ease, tubes, beams, shafts, and all sorts of rolled sections. The cutting may be made to follow any line, executing all sorts of curves and profiles; further, it is not necessarily normal to the surface, the cut being easily made on a bevel. It is evident further that the quality or the mechanical properties of the metal do not in any way modify the process; whether it be hard or soft, tempered or annealed. chrome or Harveyized, the steel burns just as fast. The problem of cutting armor plates is thus fully solved.

The essential qualities of the process may be thus summarized: Extreme simplicity of the installation and appliances, complete mobility, independence of any need of motive power, absence of any reaction upon the tool, extraordinary speed of operation, and, so to speak, unlimited adaptability.

In illustration of the rapidity which above all characterizes oxyhydrogen cutting some examples may be adduced: An armor plate 160 millimetres (6.3 inches thick) was cut to a length of 1 metre in 10 minutes. A cut of similar length in a plate 15 millimetres thick took less than 5 minutes, and the cost of the operation did not exceed 1 franc 50 centimes.

To cut a manhole 300 by 400 millimetres (12 by 16 inches) in a plate 20 to 30 millimetres (.8 to 1.2 inches thick) requires 4 to 5 minutes. An opening 150 by 150 millimetres (6 by 6 inches) in a tube 5 millimetres thick, required 3 to 4 minutes, while the cutting of the same opening with tools would need from 35 to 40 minutes. The cost of this work by the oxygen method was from 12 to 15 centimes.

Another very striking example was furnished at the station of the Metropolitan Railway at the Place d'Italie in Paris. It was necessary to cut away an iron staircase 6 metres high whose width impeded the traffic. It was cut down to a width of 1 metre in four hours' time. At Bremen, Germany, also, the method has been used for breaking up ships and among other records the following time data are interesting; a plate 300 millimetres (12 inches) thick was cut for a length of 1 metre to a depth of 4 to 6 centimetres in 7 minutes. The same plate had been cut with a pneumatic chisel along the length of 1.15 metres and to a depth of 1.5 centimetres, but this work had required an hour. The oxygen method was used also for rivet cutting; in less than 12 seconds the head of a 22-millimetre rivet could be burned without any injury to the plates. The rivet was then driven out with a punch. The maximum thickness which has yet been cut is 210 millimetres (8.27 inches) in armor plate, but 300 millimetres has been reached in round shafting. Abstract of portion of paper by J. B. Van Brussel in *Engineering Magazine.*



A PNEUMATIC TOOL RETAINER

The cut shows the essential features of a retainer for pneumatic tools recently patented by Mr. E. J. Shoffner, foreman of the Norfolk & Western shops, Roanoke, Va. One of the inconveniences of the familiar pneumatic tool is that the tool itself is always ready to drop out when not in actual contact with the working surface. The present device holds the tool securely from dropping out while still permitting the necessary freedom of longitudinal movement. The cut shows a button set in place and the following from the patented specifications sufficiently describes the device:

"The combination of a pneumatic tool cylinder, having a reduced end, a retaining sleeve, having a chamber within it, the rear of said chamber being secured to the reduced end, said sleeve having an opening through its forward portion of lesser diameter than the inner bore of the chamber, a button set having a head of such length as to always project through the opening, the head being of lesser diameter than the bore, a shoulder on said head of greater diameter than the latter and of less diameter than the bore, a comprehensible element in the chamber of less length than the distance between the button set shoulder and the forward inner wall of the chamber, and a shank on the button set of less diameter than the head and shoulder, the shank projecting rearwardly into the tool cylinder."

The cap, or retaining sleeve, is knurled on the outside so that it can be easily unscrewed and removed for changing the tool

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THE COMPRESSED AIR INJECTOR

In the Copper Queen mines, Bisbee, Arizona, the small ½-hp. electrically-driven ventilating blowers have recently been replaced by a new type of compressed-air blower, which is proving satisfactory. The principle upon which this new blower works is the same as that of an injector. A jet of compressed air passes first through a small nozzle, and then through three succeeding nozzles, each larger than the preceding one. This compressed air draws in free air around the sides of the nozzles and the whole is discharged through an air-pipe into the face of a drift or the top of a raise. The compressed air is delivered to the blower through a ½-in. pipe. The first nozzle, which is made of brass with a steel casing inside to prevent injury, has an opening $^1/_{10}$ in. diam. The comparison, as worked out with a fair degree of accuracy in the Queen, between the electric blower and the compressed-air blower, is as follows: Discharging through 300 ft. of 6-in. pipe at the elevation of Bisbee (5,300 ft.), a 330-watt electric blower delivers 300 cu. ft. of air per minute. This is known as a ½-hp. blower. The 5-in. compressed-air blower with 95 lb. air-pressure, and a $^1/_{10}$-in. nozzle takes 19 cu. ft. of free air per minute, and delivers under the same conditions 380 cu. ft. of air per minute. The cost of steam to compress the air for the air blower is about four times as great as to generate the power for the electric blower, or running them both continuously the cost of power for the air-blower is about $6 per month more than for the electric. To offset this increased expense for power, about $6 per month is required for inspection, oils, and repairs on the electric blower, while these items amount to almost nothing on the new blower. The initial cost of the electric is more than three times as great as that of the air-blower. As a rule, the compressed-air pipes are in the drifts, carrying air for the machine drills, while often electric wiring has to be done especially for the electric blower. This would be more often true in the future, as the amount of underground electric lighting is being decreased. Often a small station has to be cut for the electric blower, while the other type can be put up wherever there is room for a 6-in. air-pipe. Another advantage is that increasing the length of the air-pipe, the amount of air delivered by the air-blower does not decrease as rapidly as with the electric, on account of less friction in the blower itself. This new blower is equipped so that it can be used for exhausting the bad air from the drifts instead of blowing in fresh air, and the efficiency ought to be nearly as great. For anything larger than a ½-hp. blower, the cost of compressing the air is prohibitive; the large electric blowers being only slightly more expensive to maintain than the smaller one.—*Mining and Scientific Press.*

A placard in front of a cheap show in New York announces that the interior is cooled with "artificial air."

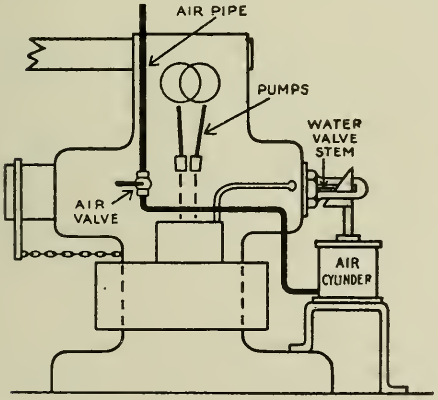
CONDITIONS OF AIR CYLINDER LUBRICATION

The fires which sometimes occur in air-compressor cylinders are due to the lubricating oil, the only combustible present. Inferior oils causes explosions by reason of the large amount of carbon and foreign substances they contain, but they are not the only oils responsible for these explosions. The conditions peculiar to a given machine may facilitate or retard combustion. For instance in a chemical works, a copper or coal mine, foreign substances in the atmosphere may furnish something to feed the fire caused by combustion of the residual carbon. Most oxidation in all cases takes place at the junction between cylinder and discharge pipe. Continual oxidation so reduces the size of the pipe that more air is compressed in the cylinder than can pass through the pipe. Increased friction and compression cause an abnormal degree of heat in the cylinder and trouble from fire is experienced. In all cases an oil should be used which causes the least oxidation possible, its flash-point being as high as consistent with good lubricating qualities. Ignition in the compressed air delivery pipe is not uncommon as shown by the explosion of two air receivers during the construction of the New York aqueduct; in one case the engine-room was destroyed by the resultant fire. The explosion was caused by the use of an oil of very low flash-point. This ignition has extended in some cases to the air receiver, and in one instance the flames were carried down into the mines by the compressed air. In some cases the pressure recorded by the gage has not been so high as that equivalent to the flash-point temperature of the oil. There must, however, have been an increase in temperature, and this is due to a momentary increase caused by the constricted air passages being choked by the deposited carbon. Trouble is increased by using too much oil, either of good or bad quality. This source of trouble is rather common, for many engineers have an idea that an air cylinder requires as much oil as a steam cylinder. Consequently deposition of carbon goes on at a very rapid rate. The carbon deposit can be removed by kerosene. Care should, however, be exercised in the use of that same, for its flashpoint is about 120 degs. F., and its careless introduction through the inlet valve has accounted for many explosions.—*Engineering Times*, London.

AIR VALVE ON HYDRAULIC WHEEL-PRESS

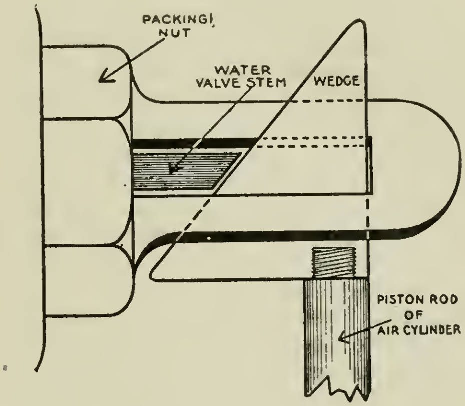
In the ordinary hydraulic wheel press as used in railroad shops and elsewhere the water which gives the pressure is controlled by a screw valve operated by a hand wheel, and when this valve is placed as usual at the end of the machine the operator is either compelled to walk to the valve every time or if he stands constantly by the valve another man has to look after and gage the wheels. The device here shown (the cut from Railway and Locomotive Engineering) was got up by Mr. J. J. Acker, car foreman of the Rock Island shops at Horton, Kansas.

In this arrangement there is an air operated valve located where most convenient for the man in charge. For the familiar screw actuated water valve there is substituted a plain compression valve which normally is held closed by the pressure of air upon a piston. The stem of this valve projects out through a specially designed packing nut which has a projection ½ in. thick standing out from it in the form of a loop about 3 ins. long. Up and down in this loop a wedge-shape little crosshead is made to move by the operation of an upright air cylinder placed below it. This piece of mechanism is at the end of the wheel press, der reaches it through a pipe so placed that the operating air valve is quite convenient for the man working the press.



AIR VALVE APPLIED TO PRESS.

When air is admitted to the cylinder its piston rises and the piston rod with the wedge-shaped crosshead goes up, the flat back of the wedge sliding along the outer end of the slot in the packing nut "loop." The wedge forces back the water valve stem and so closes the valve. When air is released from the upright cylinder its piston and rod descend, the wedge-crosshead comes down and the water pressure opens the water valve. The water valve can be opened or closed very quickly and any degree of opening may be secured according to the movement of the wedge-cross-head.



DETAILS OF AIR VALVE.

This device, which is not patented, has had the effect of greatly increasing the output of the wheel press, as the little air piston works quickly in either direction.

OXYGEN PERCENTAGE AS AFFECTED BY MOISTURE

James Moir, in a communication to the Chemical and Metallurgical Society of South Africa calls attention to the errors which may occur in the readings of gas-volumetric apparatus on account of the varying percentages of moisture in the air. Speaking of conditions on the South African plateau where he writes, the altitude being about 4,000 feet, it would appear that on a warm day with the laboratory temperature at 72 degrees, Fahr., and the vapor pressure of water as high as 20 mm. of mercury (.787 in.) the error might be quite serious. This 20 mm. at the altitude mentioned corresponds to 3.23 per cent. of water-vapor in the air; consequently in analyzing air over water the oxygen percentage of the dry air is apparently depressed by 0.7 per cent.; while the difference (reported as nitrogen) is affected by two errors, namely, the above 0.7 per cent. and in addition the actual quantity of water-vapor present. Thus a sample of air containing when dried 20.95 per cent. oxygen, 0.05 per cent. CO_2, and 79.0 per cent. nitrogen when introduced into an Orsat at 72 degrees F., will expand by 3.33 per cent.; and the analysis will give $CO_2=0.05$ per cent., $O=20.25$ per cent., residue=79.7 per cent. Seeing such an analysis, one would suppose that some of the oxygen had been used up, but in fact the apparent deficit is due entirely to dilution with water-vapor. Again, 3.2 per cent. of the residue is water-vapor, so that the true value of the inert gases (mainly nitrogen) in the saturated sample is 76.5 per cent.; the depression from 79.0 per cent. corresponding exactly with the dilution of the dry gas with 3.33 per cent. of water-vapor. Consequently, to get comparable results with such apparatus, it is necessary to recalculate the observed readings. It would be more correct theoretically to use in the calculation the actual percentage of water-vapor present at the time of sampling; but in practice it is usual to calculate back to dry air, so as to be able to compare directly with the existing standard analyses of fresh air. Thus if the observed readings are: $CO_2=0.1$, $O_2=20.2$, residue=79.7, and the temperature of the water is 70 degrees F., the barometer reading 620 mm., that is, vapor pressure=18.6 mm.. then percentage of water-vapor is $(18.6/620)\times100=3.0$ per cent. Consequently 100 c.c. of the wet gas contains $CO_2=0.1$ c.c., $O_2=20.2$ c. c., N_2, etc.=76.7 c.c., $H_2O=30$ c.c.; which quantities are also contained in 97 c.c. of the dry gas; therefore the true analysis of the dry gas is (multiplying the figure by ${}^{100}/_{97}$), $CO_2=0.103$ per cent., $O_2=20.825$ per cent., and N_2, etc.=79.072 per cent.

An example of such a fallacy is the deficiency of oxygen always observed in mine air. The atmosphere in mines is usually near saturation, and consequently dry air entering the downcast with, let us say, 21 per cent. oxygen, will through mere dilution with water-vapor contain only about 20.5 per cent. by the time it reaches the foot of the shaft. In spite of this elementary fact, many scientists have attributed the fall in oxygen to such things as the oxidation of pyrite or timber. It should also be noted that the state of humidity of the air also affects the results of CO_2 determinations by Pettenkofer's method, but only to a slight extent. The observed barometric pressure should be diminished by the existing vapor tension at the time of sampling.

THE FAN BLOWER IN INDUSTRIAL HYGIENE

The report of the Massachusetts State Board of Health gives large space to the general topic of ventilation, and especially in presenting evidence of the easy possibility of vastly improving conditions by the employment of suitable apparatus. When dust or fumes are formed in industrial operations they may be assumed to be always injurious and often dangerous, and they should be systematically taken care of.

The fan blower is shown to be the one reliable device for this purpose. Its positive and controllable action makes it applicable to all conditions, and the ready means of rendering practically harmless many occupations which are otherwise exceedingly unhealthy. It is primarily essential that the fan be locally applied, that is, that the source of dust or fumes be so hooded and connected with the fan that whatever is objectionable may be immediately drawn away, and not allowed to escape into the room.

In each industry there are applications peculiar to its own processes, but the general public has little knowledge of the methods employed. Perhaps the most familiar application of the fan for the handling of refuse and the removal of dust is in the planing mill where each machine is hooded, and such a vacuum is produced in the connecting pipes that the fan is enabled to convey the waste material throughout long distances, pass it through dust collectors, and allow the clarified air to escape to the atmosphere. while the shavings and sawdust are as quietly deposited as may be desired.

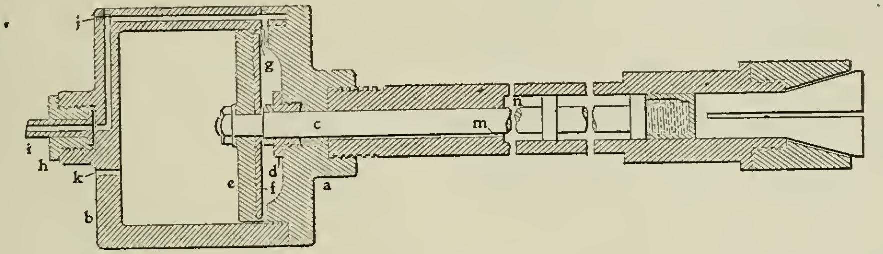
In the shoeshop the fan is almost universally employed to remove the fine leather dust from the buffing wheels and other shoe-working machines. Here close hooding is necessary to economize the volume of air handled by the fan.

In the manufacture of derby and felt hats the essential material is fur heated with cyanide of mercury. Separation of coarse from fine hair is accomplished under the action of powerful suction.

Mechanically operated exhaust systems find helpful applications in connection with machines for pointing the pins of horn and celluloid combs, the "dusters" used for cleaning paper mill rags, the hydroflouric acid tanks of the glass cutter, the polishing lathes used by the manufacturer of optical lenses, and in the machine shop, the textile mill, the match factory, the lead works, and a hundred other industries.

In a system applied to a series of brass grinding and polishing wheels, each hood is so constructed that by means of the swinging side plate the wheel may be readily replaced. Visors at top and bottom of the hood may be adjusted so as to include any desired portion of the wheel. The lighter dust is carried away by the air passing through the fan, but the heavier metallic particles fall into a hopper below, whence they can be periodically removed.

There is manifestly no limit to the variety of applications of the fan blower which may be made to improve hygienic conditions. It is perfectly evident that the objectionable features obtaining in most industries may be thereby removed, or their influence may be reduced very much, with a material result in the healthfulness of employees.



A PNEUMATIC CHUCK.

A PNEUMATIC CHUCK

The cut herewith, from the *American Machinist,* shows a pneumatic chuck for use on monitor lathes in place of the usual lever used to operate draw-in checks. It may be used on castings or any work that does not require an open spindle. One with a 5½-inch bore, used at 75 pounds air pressure, will be found large enough for average size work in brass. This size is strong enough for the use of a 2-inch pipe tap.

Referring to the sketch, which shows it on a lathe spindle connected up, the cast-iron body *a* is threaded to screw on the end of the spindle. The other side is threaded for the cast-iron cap *b,* which should be bored accurate and highly polished. The body is bored a sliding fit for the draw rod *c* and bored and threaded for the nut *d.* This chamber and the end of the nut should be tapered, on the face, as in sketch and used as a packing box, preventing the escape of air into the spindle.

The piston consists of the cast-iron plates *e* and *f* with the leather cup disk *g* between them. The plate *e* should be a loose sliding fit, the leather disk serving as the air check. The end of the cap is bored and threaded for the nut *h* which is bored, and the end tapered and fitted with the brass nipple *i,* the taper of which is ground to the nut; *j* is the air passage drilled through from the outside, running from the nipple chamber to the body bringing the air back of the piston. The holes in the outside are plugged with small studs screwed in; at *k* is a small hole to allow the air to escape as the piston moves. The drawing rod *c* is fitted in the spindle as usual in this style of machine, with the key *m* fitting the keyway inside of the spindle, and a coil spring at *n,* to draw back the rod when the air is released.

The short brass nipple *i,* is fitted to a union and the air pipe which can run down in front of the machine and at a convenient position the cut-off cock may be inserted. A plug cock with a waste hole drilled in one side through both body and key may be used. This waste hole is to allow the compressed air to escape from the cylinder as the cock is turned off.

TUNNEL DRIVING AT LOW COST

By Walter H. Bunce.

The driving of the Chipeta adit at Ouray, Colorado, was not especially notable as an important operation, but on account of the rapid driving and the resultant low costs, attention was attracted to it. The adit was projected as a working entry to simplify the mining of the American-Nettie quartzite stratum, which had faulted downward. The old entries were tortuous inclines terminating at the fault. The portal is in the face of the steep mountain forming one wall of the canyon north of the town of Ouray, at an altitude of nearly 9,000 ft. and 1,700 ft. above the bed of the river. For economic reasons the power-plant was placed at the river and a line of 3½ in. standard pipe was laid on the surface to carry compressed air to the adit. This pipe-line, 3,400 ft. long, has given no trouble in summer or winter.

During the installation of the plant and pipe-line, work was carried on by hand-labor, the adit reaching a length of 263 ft., including the portal section of 115 ft., which was heavily timbered 7 by 7 ft. in the clear. Machine-drilling was then started and a run, which lasted for five full months, was made, only two rounds of holes being lost in that period.

This run of five months (152 days) resulted in driving the heading 7½ by 7½ ft. in the clear, a distance of 1,712½ ft. in hard rock; a monthly average of 342½ ft. The best weekly record was 85 ft.; the best month (31 days) was 359 ft. But two 8-hour shifts per day were employed. Compressed air at about 100 lb. was supplied to a pair of 3 1-8 in. New Ingersoll drills, both mounted on one single-screw column set horizontally above the muckpile. The round, consisting of from 15 to 19 holes, was drilled—except the lifters—from this setting, the bar being re-set for the lifters after the muck was away. The 'cut' was taken from the bottom, uniformly. Three drill-men tended the two machines, drilling a full round each shift.

An unusual system of 'mucking' was employed, which, perhaps more than any other one thing, may account for the substantial rate of progress. The tunnel track, 18-in. gauge, was carried close to one side of the adit, and a floor consisting of steel plates and planks was maintained with the greatest care for not less than 60 ft. back from the heading. This floor was moved forward every round. No switches or turnouts were used; cars measuring 20 cu. ft. capacity were specially designed and these, although weighing empty 1,000 lb. apiece, were so perfectly balanced that the empty cars composing an incoming train were easily 'jumped' off the track on to this floor, the loaded cars passed by, and then the empties replaced on the track in detail as required by the muckers for loading. Muck was handled with No. 6 square-pointed shovels. Four shovelers and a mule-driver composed each shift. Track was laid and leveled by the muckers. Each shift, composed of drill-men and muckers, started work together. No ventilating system was installed, the smoke being blown back with air from the compressor. The adit throughout its entire length was perfectly dry.

This adit was an independent operation, the employees having no other occupation, so that their total wages are a charge against the work. Their wages were: Foreman, $5; drill men and blacksmith, $4; blacksmith-helper, $3.50; muckers, $3; compressor-engineers, $3.50 per 8-hour shift. No bonuses were paid except on Christmas day, when double time was given. The following costs are computed from March 1, when 1,835 ft. (including the portal section) had been completed, and embrace every item outside of construction and equipment accounts, which were closed before the current accounts were opened. The 'Power' account covers labor, coal, oil, and lights, everything at the compressor station; 'Labor' covers all other labor except that charged into 'Lumber and Timbers.' 'Tunnel Expense' covers tool-renewals and repairs, blacksmith's sundries, forage, oils, and general sundries at tunnel; 'Track and Pipe' covers cost and transportation of rail, fittings, ties, pipe, and pipe fittings; 'Expense' covers city office, rent, furniture, and incidental expenses. The compensation of the acting superintendent is nowhere included in the costs as shown.

Distribution of costs.	Total.	Cost per foot.
Tunnel expense	$556.94	$0.303
Track and pipe	1,532.26	0.835
Power	2,862.71	1.560
Lumber and timber	533.51	0.291
Labor	11,981.85	6.529
Lights	233.70	0.127
Explosives	3,522.06	1.919
Expense	836.11	0.455
(1835)	$22,059.14	$12.02

Pipe-line through tunnel is 3½-in. standard black pipe. Track is 16-lb. section, on ties laid 20 in. apart. Powder (40 per cent. dynamite) cost $0.1315 at the portal. Close estimation places its consumption at 14.5 lb. per foot for machine-driving. Steam coal cost $3 per ton at the boilers. The air-pressure was nominally 100 lb. and a recording gauge kept on the line proved of value in many ways. There was always plenty of air. No charge for depreciation of tools and equipment has yet been entered; renewals and repairs are made and charged currently to 'Tunnel Expense' and the actual value of the outfit to the company is about equivalent to new, as nothing has been allowed to run down.—*Mining and Scientific Press,* San Francisco.

DIFFERENT POWER COSTS FOR STEAM DRIVEN COMPRESSORS

Chas. D. Havenstrite, in a series of papers recently current in the Cold Storage and Ice Trade Journal discussing in detail the several features of the refrigerating machine calls attention to the different possible rates of steam and coal consumption in operating the compressor, the most responsible portion of the apparatus. As the matter is entirely pertinent to steam actuated air compressors for whatever purposes employed, and as it enforces a lesson not yet fully learned, this portion of the paper is here reproduced and is commended to the attention of all who should be interested.

There are three usual types of steam engines employed for air compressors: the simple slide valve, simple "Corliss" and the compound condensing "Corliss" engine. The steam used by these will be about as follows:

Simple slide valve, 60 lbs. of steam per H. P. hour.

Simple "Corliss," 26 lbs. of steam per H. P. hour.

Compound condensing "Corliss," 18 lbs. of steam per H. P. hour.

In order to compare what the fuel consumption of each of the above will be, we will consider a 25-ton refrigerating machine. Allowing 1¼ H. P. per ton of refrigeration, a 25-ton refrigerating machine will require a 31¼ H. P. engine. Each 25-ton machine will then use the following pounds of steam per hour:

Simple slide valve, 1,860 lbs. of steam per hour.

Simple "Corliss," 806 lbs. of steam per hour.

Compound condensing "Corliss," 478 lbs. of steam per hour.

Assuming an evaporation in the boiler of 7 lbs. of water per pound of coal, which is average, we have:

Simple slide valve, 266 lbs. of coal per hour.

Simple "Corliss," 115 lbs. of coal per hour.

Compound condensing "Corliss," 68 lbs. of coal per hour.

And for 24 hours operation:

Simple slide valve, 6,384 lbs. of coal per 24 hours.

Simple "Corliss," 2,760 lbs. of coal per 24 hours.

Compound condensing "Corliss," 1,632 lbs. of coal per 24 hours.

It is thus evident that there is quite a difference in the fuel consumption of the three types of steam engines and it is also evident that each machine will require a different size boiler to operate it. Thus a boiler just large enough to operate a simple "Corliss" engine will operate a compound condensing "Corliss" engine with ease and good boiler economy in addition, while it would be totally unable to operate a slide valve engine of the same horsepower.

It is not usual practice to use a "Corliss" engine on machines under 15 to 25 tons refrigerating capacity, as a "Corliss" of such small horse-power becomes more or less troublesome. Further, machines of such small size are not always run by skilled men and it is therefore better to furnish the simplest type of engine. But with the larger sizes it is well to consider whether a simple or compound condensing "Corliss" engine is to be used, as the difference in fuel consumption becomes quite large and usually warrants the higher cost for the more economical of the two.

HYDRO-OXYGEN METAL CUTTING

Oskar Kylin, of the editorial staff of *Machinery* is visiting shops in Europe and sends readable and interesting notes of things seen there. The following from the Borsig Works, at Tegel, near Berlin, puts us in closer touch with the actual operation of cutting metals by burning. He says:

As is well known, the principle involved in this method of cutting iron is the use of the oxidizing effect on the metal, or, in other words, the actual burning of the iron. In order to cause rapid combustion of the iron when the oxygen is applied to it, it must be heated to a temperature of 1,300 to 1,500 degrees F. before applying the oxygen. This pre-heating of the iron is accomplished by a burning jet of hydrogen and oxygen. The apparatus for cutting the iron consists of two nozzles, arranged to follow each other, the first nozzle pre-heating the iron, and followed by the second nozzle for the application of the oxygen, this causing combustion of the iron, and executing the cutting. The two nozzles are arrange so that the oxygen will always strike exactly the same spot which has been pre-heated by the preceding flame.

It is important that the cutting nozzles be moved at a certain correct speed. If the cutting nozzles are moved too slowly, the continuous cutting will be interrupted, because the iron will get time to cool off before being struck by the stream of oxygen from the second jet. If, again, the nozzles are moved too quickly, the oxidizing effect will not be complete, and the cutting will not reach through the piece to be cut. With some practice, however, it is not difficult to learn by experience the correct speed for any particular work. When properly done, a cut made by this method is very smooth and equals a sheared cut.

It might be assumed that the material would be severely attacked on the surface by the influence of the oxygen, but this, however, is claimed not to be the case. With the exception of a layer of 0.01 inch, at the most, next to the cutting edge, the material keeps its original chemical composition, and the physical qualities remain the same. It is claimed that pieces of iron up to a thickness of twelve inches may be cut by this process. Of course, the exactness of the cut changes with the different thicknesses. At a thickness up to 2 inches, the process may be carried out within limits of 3-64 inch, while at thicknesses of from 2 to 4 inches, the limit attainable is 3-32 inch, and above 4 inches it is still larger. The width of the cut, of course, also increases with the thickness of the material.

The blow-pipes are connected with flexible piping to the tanks filled with the respective gases. As the pressure in the tanks is high, being about 150 atmospheres when filled, the gas passes through a pressure reducing valve before being used. The pressure of the oxygen, when used for cutting, varies, depending upon the thickness of the material, from about 1½ to 5 atmospheres.

As a matter of curiosity, some work done by the assistance of the hydro-oxygen jet may be mentioned; when visiting the Deutsche Oxhydric Co., the writer saw a large bunch of grapes with leaves and branch of the vine, which, by the aid of the hydro-oxygen flame had been made from ordinary thin sheet iron. The imitation was good and, although the piece was of iron, it was very light. There was also a branch of a pear tree, with a large nice-looking pear, and two leaves, and also a lily of the valley made in the same way. As a souvenir, the writer received a cup made, during his visit, from welded pipe, by the aid of the same process. The pipe was chucked in a lathe and then heated by the gas jet, and at the same time pressed to shape by hand by a plane tool.

REGULATING HUMIDITY IN FACTORIES

The control of humidity of air rendered possible by the air-washing system was well shown in a series of tests recently made at a cotton mill in Belmont, N. C., in which there is installed an air-washing equipment in connection with a hot-blast heating system having a fan of 25,000 cu. ft. capacity per minute. The mill is a two-story building with 5,000 spindles and a cubical content of about 170,000 cu. ft. per floor. Two tests were recently made with the system, one with the humidity at a very low point, one of the dryest days of the month, and the other at a time when the humidity was exceedingly high. On the first test the outside air ranged between 9.30 a. m. and 3 p. m., from 44 degrees to 52 degrees, dry bulb, from 36 degrees to forty degrees, wet bulb, and from 40 to 30½ per cent. humidity, but the air left the air washer at a humidity of from 96 to 97 per cent. and that in the card room was held at about 61½ per cent., in the spinning room 69½ per cent. and 83 per cent. in the winding room. In the second test, the outside temperature was constant at 48 degrees, dry bulb, and 47 degrees, wet bulb, and 95 per cent. humidity, and the air leaving the humidifier had a humidity of 96½ per cent. The humidities thus secured within the mill were 64 per cent. in the card room, 70 per cent. in the spinning room and 87 per cent. in the winding room. The air washing and humidifying equipment was installed by the Buffalo Forge Co.

UNWELCOME AIR BLASTS

The Quincy, one of the oldest and most extensive of the mines in the Michigan copper group, is troubled by air blasts caused by the falling and settling of rock in the many miles of abandoned workings. The falling rock causes compression of the air in other parts of the mine, and sometimes the shock of the fall and the compression is sufficient to cause a miniature earthquake which may be felt for several miles around. The distturbance comes without warning, at times killing or injuring the workmen.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC
Established 1896

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UNDER-GROUND WATER SUPPLY FOR CITIES

The safest, best and cheapest water is secured under ground; if obtained in gravel with a reasonable overlay of clay or from the rock itself, there is little chance for any contamination. Sand stone or lime rock wells produce the purest and best water that can be obtained. Shale sometimes produces water that has a peculiar odor and taste that is objectionable, and frequently shale water is salty. In most localities rock water is secured within two or three hundred feet of the surface of the ground; in a few exceptional cases it has been found necessary to go down 1,500 to 2,000 feet. A great many of the wells in Chicago are 1,600 feet and pumped with compressed air. Whatever the depth may be, this is the surest, safest and cheapest method for producing water, and it is a rare instance when water can not be obtained by drilled wells. Some cities get their water supply from rivers or lakes and filter it. This is only, however, when the underground water is found to be salty or contain such chemical properties as render it objectionable. When preparing to secure water for towns or villages, the first course to pursue is the preliminary prospecting to find the best and most available supply. Small holes can be used, usually from 5 to 6 inches, as water can be tested for quality and quantity in this size hole and the expense of drilling them is not so great as is the case with a larger size. The prospecting should cover a large area, and it frequently happens that more water supply is found within a radius of half a mile or frequently a good supply is found in the gravel and also in the rock below. After locating what appears to be a good supply, samples should be taken and submitted to the state board of health, or some other reliable laboratory, where they are equipped to make a reliable analysis. After it has been determined that the quality is good, the water can be tested for quantity by any of the well known methods.

THE DRY AIR BLAST IN THE BESSEMER CONVERTER

The Gayley dry-air blast system having been used with such marked success in several blast furnaces in the last two or three years, arrangements were recently made at the South Chicago works of the Illinois Steel Company to try the effect of the dry blast in the bessemer converter also. A run of two days was made, the average reduction of moisture in the air blown into the converters being from 5.98 to 1.39 grains of moisture per cubic foot.

The results obtained were remarkable, and may mark an epoch in steel manufacture. Throughout the test a better and more nearly uniform grade of steel was produced. The ingots cast were more solid, free from blow holes, except at the extreme top, and the blooms made from them showed unusual solidity and freedom from segregation. With the usual discard, the blooms were used in rolling 100 lb. section rail, and in the tests only 1 per cent. of the rails, a very unusual proportion, were rejected as defective or of second quality. The results obtained were further encouraging in the direction of increased capacity for carrying scrap and other items bearing on cost, and in the enlarged control of high or low silicon irons.

The test spoken of was on such a scale and so carefully made that it would seem to fully confirm Mr. Gayley's claims for the advantages of using dry air in the converter as well as in the blast furnace. It may be of great importance in restoring confidence in the bessemer process, and in putting the converters again on a parity with the open hearth furnaces as far as the quality of the product is concerned.

This application may contribute largely to the solution of the steel rail question which has been so insistent of late. With similar results to be depended on in continuous operation there will be no longer necessity of abandoning the bessemer converter and adopting the open hearth furnace for rail material.

INCIDENTAL LESSONS IN ROCK DRILL TESTS

At the June meeting of the South African Association of Engineers Mr. E. J. Laschinger gave some interesting particulars of tests which had been made at the Meyer & Charlton mine with the New Ingersoll and the Konomax drills, the latter a local production. The chief results of the tests were:

(1) It was proved that the ordinary 1-in. pipe and 1-in. air hose were not of sufficient capacity to serve 3¼-in. drills satisfactorily. (2) The necessity of renewing the pistons, valves, and other accessories of the rock drills more frequently than is the present practice was apparent from the higher results achieved by new drills as compared with those which had been runing for some time. (3) Contrary to the general opinion, it was found that the loss of pressure from leakage underground (and it must be stated that the Meyer & Charlton is an old mine, and the connections have been established for years) was less than 5 per cent.

There are a number of experiments being conducted on these fields in connection with rock drills, with a view of determining the most economical pressures and other matters which concern the effective power of the drills. These experiments are welcomed by the mines, as they all tend in the direction of increased efficiency.

REMOVING IRON FROM WATER BY AERATION

Dover, N. H., obtains its water supply from several springs located in low ground, just below a sandy ridge, the water being collected in 2,000 feet of 10-inch vitrified sewer pipe laid with open joints from 10 to 12 feet below the surface. The water from some of the springs contains a considerable amount of iron, sufficient to make it undesirable for washing white clothes in, and those springs were cut out from the supply for some years. It was later decided to use this water and endeavor to remove the iron from it as far as possible. The ordinary method of accomplishing this is by aeration, which renders the iron insoluble, followed by removal of the precipitant by filtration. Under the advice and direction of William S. Johnson as consulting engineer, the apparatus described herewith was built, as a temporary affair only.

The sod and loam were removed from a plot of ground about 400 by 150 feet, situated 400 feet above the springs from which the acceptable water was obtained, thus exposing a sandy soil, whose elevation was 27 feet higher than the vitrified collecting pipe-line. The iron-bearing water was pumped to the filter bed through 400 feet of 4-inch pipe, which, at the bed, was connected to two lines of 2½-inch pipe, in the top of which were drilled ⅛-inch holes in four lines. The pressure from the pump forced the water through these about 10 feet into the air, and as it fell onto the sand bed in the form of spray it absorbed the desired oxygen. Passing down through the way to the springs which were being utilized. sand, the water was filtered and found its and from them to the collecting line.

The superintendent states that they undoubtedly lose a part of the water which is pumped but analyses appear to indicate that 95 per cent. of the iron has been removed from that collected, and the plant may, therefore, be said to be to this extent a success. *Municipal Journal.*

AN AIR JET HELPS THE LOADING

In excavating for the foundations for the Hudson Terminal Buildings there was a great mass of material to be handled, much of it consisting of stiff wet clay and quicksand. This material was first loaded into a bucket which was hoisted close up to a traveler suspended under an I beam and then run over a hopper where it was dumped. Wagons would then come in succession under the hopper and each take its load. The water from the quicksand puddled the clay and compacted it so solidly at the bottom of the hopper that when the sliding door was opened to let the load down into the wagon the clay arched itself so that it would not slip by gravity and it was necessary to keep three to four men on a platform over the hopper to cut the material and free it with heavy slice bars. It took about 10 minutes to load a two yard wagon in this way, and it was seldom that more than 60 loads per day could be loaded from one hopper.

There being a constant supply of compressed air on the work it was resorted to for relief in this case. A pipe was run from the compressor with a valve convenient for the men on the platform. A hose was attached to the pipe and at the end of it a piece of 1 inch pipe 4 or 5 feet long was fastened. This pipe was run down into the dirt and when the air was turned on it caused the material to slide freely and the wagon was quickly loaded. The number of wagons was at once increased and in ten hours from 100 to 120 wagons were loaded from each hopper.

The cost of the work was materially reduced by this means—blown away, we might say—as the number of teams was doubled and the daily excavation considerably increased, thus saving on the fixed charges. The labor of nine men was saved on the three hoppers. The cost of the air was scarcely appreciable in comparison with the results. A 2 inch pipe ran from the compressor with air at 80 lbs., but the jet was used only a small portion of the time.

QUESTIONS AND ANSWERS

W. G. C., Savannah, Ga. *Q.* In the little article in your August issue on "Record Driving in South African Mines," it is stated that with the air at 80 lbs. gage, at the surface the working pressure at the drills was not less than that, notwithstanding the usual reduction of pressure due to the friction in the pipes. The gain in air pressure at about 4,000 feet, it was stated, equals 10 lbs. per sq. in. Some months ago in Compressed Air a rule was given for roughly approximating the pressures of air at different depths, which was to add 20 per cent. to the absolute pressure for each mile of depth. Then 20 per cent. of 14.7 would be 2.94 lbs., and for 4,000 feet, or say ¾ mile, it would be only 2.2 lbs. instead of 10 lbs. Which is correct?

A. Both are approximately correct, one of them for atmospheric air and the other for air compressed to a specified pressure. The weight of a cubic foot of air at normal pressure and at 60 degrees, Fahr., is .0764 lb., and as 80 lbs. gage is 6.44 atmos., the weight of a cubic foot at that pressure would be .0764x6.44=.492 lb. Say that we had a pipe with a sectional area of 1 square foot, 144 sq. in., and with a vertical height of 4,000 feet, then the weight of the air in the pipe, independently of any pressure above it, would be 4,000×.492=1,968 lb., and 1,968÷144=13.66 lbs. per sq. in. The total weight would, indeed, be considerably more than this on account of the compression of the contents of the lower portions of the column by the weight of all above. Unless the piping were outrageously inadequate the loss by friction of flow should be much less than this, and there should be an effective working pressure of probably 90 lbs., while the atmospheric pressure at that depth against which the drills would deliver their exhaust would be only about 3 lbs. above the surface pressure.

TRADE PUBLICATIONS

Progress Reporter, No. 18, Niles.—Bement-Pond Co., New York. 20 pages, 9 by 12 inches. This shows a number of new tools recently turned out, a 90 inch Niles Tire Mill, a massive combination slotting, boring, drilling and milling machine, a 16-25-foot heavy pattern extension boring and turning mill, several new lathes and other tools.

Works and Products of Allis.—Chalmers Co. 48 pages, 5 by 6 inches. The seven plants of this company are illustrated, the aggregate floor space amounting to 74 acres, and the total ground area to 250 acres; the products mentioned include pumping engines, hydraulic turbines and centrifugal pumps, gas engines and power engines for all services, steam turbines, crushing, mining, floor mill and saw mill machinery and numerous other products.

Record, No. 65, Baldwin Locomotive Works, Philadelphia, 48 pages, 6x9 inches. This is a reprint of a paper on the Mallet Articulated Compound Locomotive read before the Engineers' Club of Philadelphia by Grafton Greenough, with discussion by S. M. Vanclain. Copiously illustrated and finely printed.

The Barco Flexible Joint, Barco Brass and Joint Company, Chicago. 16 pages, 6x9 inches. This joint is described and shown in detail as to construction and a wide range of adaptability is suggested in the illustrations of the joint in actual use. Full dimensions of the different sizes are given.

Bulletins 1—6, United Store Service and Tube Company, Boston. These bulletins describe cash carriers, parcel carriers, pneumatic despatch tubes, used in stores and factories and in connection with telegraph, postal and other service.

Coal Handling Machinery, Conveyors, "Industrial," "Railways," Stevedore Rope. C. W. Hunt Company, West New Brighton, N. Y. 48 pages, 6 by 3½ inches. "An introduction to the general line of labor saving machinery manufactured by the company." The pamphlets issued by this company make effective use of little half-tones, about 100 telling their stories in these pages.

There have been issued recently by the Ingersoll Rand Company, 11 Broadway, New York, four pamphlets designated as follows: 36A, Compressors; 47A, Rock Excavating Machinery; 21A, Electric-Air Rock Drills and Channelers; 74B, Pneumatic Pumping Systems. These have each 24 pages, 6 by 3¼ inches and slip into a regular letter envelope or an inside pocket. They are copiously illustrated and contain in compact and handy form a great amount of essential information concerning the lines of apparatus indicated.

ALTITUDE STRENGTHENING THE HEART

The *Journal of Tropical Medicine and Hygiene* notes the fact that the Transvaal Medical Society has appointed a sub-committee to investigate the clinical and physiological effects of altitude upon persons resident in high localities, and says:

"The Transvaal is an upland, Johannesburg being some 6,000 ft. above sea level. The increased pulse-rate observable in the locality is attributed to altitude, and although it is said a healthy man can adapt himself to any degree of altitude, there is some doubt as to the scientific accuracy of this statement. The increased pulse-rate may require some hypertrophy of the heart muscle, a condition actually observed in a certain proportion of school children in Johannesburg schools. The importance of this condition would seem to centre chiefly around a question of longevity, and it would be interesting to determine the average length of life to which adults attain at these relatively high altitudes."

It is a fact that though Johannesburg is a young city, it already numbers among its inhabitants not a few men of advanced age who appear to be at least as active as those of similar years elsewhere. Longevity amongst the Boers, many of whom have lived nearly all their lives at altitudes similar to that of the Rand, is notorious. "Hypertrophy of the heart muscle" may sound very serious to the average layman, but in plain English it is nothing more than the strengthening of that organ to meet the needs of new conditions, or, in other words, it is the organism adapting itself to its environment. The change from low to high veld in South Africa often acts as a decided tonic, and should prove beneficial in the majority of cases even of impaired health, though where there is reason for doubt a medical man should certainly be consulted.

THE AERODROMETER

In the course of a research into the respiratory movements, Prof. Zwaardemaker, of Utrecht, has devised a very simple apparatus for determining the velocity of gas streams, an apparatus which seems to be capable of application for mechanical as well as for physiological experiments. This aerodromometer consists of a vertical glass tube, about 25 centimetres (10 inches) in length and 1 or 2 centimetres (0.4 to 0.8 inch) in diameter, in the middle of which a disc of aluminum is suspended by two spiral springs attached to the extremities of the tube. The air enters above through a number of inlet openings which nearly take up the whole of the cross section of the tube. The aluminum disc does not completely bar the passage, and an annular clearance is left between the disc and the cylindrical glass walls. When experimenting on the breath, the clearance is made rather wide—as much as 2.5 millimetres (0.1 inch)—not to obstruct the ment. When more powerful air currents are breath, which is very sensitive to any impedito be measured, the clearance may be reduced to 0.5 millimetre (0.02 inch) and the sensitiveness of the apparatus thereby be increased. The instrument is empirically gauged by means of a constant air current, produced, for instance, with the aid of a water-jet pump or an electric fan or blower; for the apparatus answers both for suction and pressure observations. The aerodromometer itself checks the constancy of the air-current to be measured. The deflections of the disc depend upon the velocity of the air-currents and upon the apparatus and its dimensions.

Using a tube with six inlet openings aggregating 0.93 square centimetre (0.144 sq. in.) and a clearance of 0.44 square contimetre (0.068 sq. in.) Zwaardemaker observed the following deflections, measured in millimetres, with air volumes measured in cubic centimetres per second:

1	millimetre..........	12	cubic	centimetres.
2	"	23	"	"
3	"	35	"	"
4	"	46	"	"
5	"	58	"	"
10	"	86	"	"
15	"	105	"	"
20	"	121	"	"
30	"	154	"	"
40	"	179	"	"
50	"	200	"	"

Further tests have been made with the aid of J. T. van Have's breath-volume recorder. Two of these latter instruments were placed on the two sides of a pendulum, 2.3 metres in length, in such a way that each oscillation of the pendulum sent an air-current through the Have instrument, which recorded the air-volumes. Each of these instruments was connected with an aerodromometer, whose oscillations were likewise photographically recorded. In this way two synchronous curves were obtained: a volume curve of the sine type, and a velocity curve of the cosine type. The two curves were found to be in complete accord, and it would thus appear that the aerodromometer, which is made by the firm of D. B. Kagenaar, sen., of Utrecht, is suited for recording the velocities of air-currents alternating in direction at a fairly rapid rate.

SCRUBBING BUILDING FRONTS

There has recently been adopted, for the first time in Edinburgh, a new method of cleaning and renewing the frontage of buildings. Hitherto of the systems employed, that of washing the face of the building with sandstone and water has found most favour. An innovation is now being carried out on the Union Bank in George street by Mr. W. Forrest, builder, Comiston-road. A double process of treatment is employed. First of all, the face of the structure is cleaned with carborundum. Made up in the form of briquettes, so as to be suitable for handling by workmen, it is applied by rubbing to the face of the stone. This having been done, the second stage of the cleaning operation is carried out in the application of a chemical composition named "Lithoderm." This substance searches the inner recesses that may have been missed in the first process, and the result of the whole is to give to the building thus treated a fresh, clean, and new appearance. *The Quarry*, London.

Can it be that these good people have never heard of the sand blast? They should have seen how the front of the New York City Hall was cleaned three or four years ago.

BLAUGAS

The rights to make and sell Blaugas in Canada and the United States have been secured by some Americans who propose to build a factory near Newark, N. J., where ground has been secured. The company was formed for the purpose of taking over and operating the patents of Herman Blau of Augsburg, Germany, covering the production and liquefaction of gas, derived from crude oil. This gas liquefies under compression to about 1-400 of of its original volume, and is then introduced into steel flasks, in which shape it is distributed to consumers. A committee of experts recently returned from Germany where they made a close investigation of the gas and its uses, and their report is commendatory. Blaugas is coming into general use abroad for all purposes for which ordinary gas is utilized. Besides its value for technical purposes, for which Blaugas commends itself on account of its high calorific properties, which make it valuable for welding, soldering, and the like, it is available for many uses out of reach of ordinary gas. In this direction Blaugas encroaches, to a considerable extent, on the field now exclusively enjoyed by electricity, principally in the matter of decorative effects. This comes very near encroaching on the preserves of compressed acetylene cylinders now so largely used on automobiles.

THE BIGGEST SEWER

The largest sewer in the world is in St. Louis. When the Harlem Creek sewer, now in process of construction, is completed, this city will possess a sewer with a large section of 29 feet diameter and smaller sections ranging from 27 to 18 feet in diameter, the main section and two branches measuring over four miles in extent, and the whole draining more than 6,000 acres of land. There are longer sewers than this, and there are drainage systems, not sewers, which drain much larger tracts of land, but there is no sewer in the world that combines such great size with extent of area drained, and there is no city drainage system in the world that in any way compares with it.

The Harlem Creek sewer was begun July 13, 1906, and Sewer Commissioner Fardwell expects to have the public section or that section running from Florissant avenue to the river completed within another year. The entire system will probably not be finished for three or four years more, and all the connecting lines will not be laid till the section drained becomes more thickly populated. The Harlem Creek District is the largest drainage area in the city, and that is why such a large sewer is being constructed. Over 800 of the 6,000 acres drained are outside the city limits, but the character of the land is such that its drainage had to be provided for in planning for a city sewer in the district adjacent to it. The natural slope of the ground sends all the water from Harlem Creek and its tributaries into the sink followed by the line of the sewer, and even though the city cannot run sewers outside the city limits, in this case it is compelled to take care of the drainage of a large section of land beyond the limits in order to protect the sewer area inside the city.

DRILL STEEL

At a recent meeting of the Chemical, Metallurgical and Mining Society of South Africa Mr. Lane Carter discussed the subject of economy in drill steel. By economy was not meant false economy. Cheap steel is usually the most expensive in the long run. It is much better to get a good quality of steel even if the first cost is high.

By sharpening drills underground vast economies could be effected. The recent experiments with an underground electric furnace show that this point is recognized, and no doubt the difficulties connected with it will be overcome at no distant date. The hoisting of all drills to the surface through 4,000 feet shafts in order to sharpen them is absurd on the face of it. A problem that has yet to be worked out is the question of the relative merits of machine sharpening and hand sharpening of drill steel. Mr. Lane Carter's experience is that hand sharpening pays best. It would surprise most people to know how much drill steel is lost underground. Kaffirs and Chinamen have a way of hiding steel. On every mine there are tons of steel stored away underground and lost for ever. This could be remedied by treating the hand men in the same way as the machine men, namely, by giving them all a certain number of drills with a distinctive mark and making them responsible for them. This scheme has been tried on one or two mines with great success. The initial expense of getting out sufficient steel is considerable, but the saving in the long run is enormous.

NOTES

The Cleveland-Cliffs Iron Company has decided to put in a Gayley dry-air blast plant at its Pioneer No. 2 furnace at Marquette, Mich. The work will be begun soon.

The Northwestern Iron Company has lately increased its capital, and has begun to make extensive improvement in its mines and its furnace at Mayville, Wis. Among these improvements will be a dry-air plant for the blast furnace.

The cost of pumping water, per million foot gallons at the different stations of the Metropolitan (Boston) water works during 1907, was as follows: Chestnut Hill high-service, 2.8 cents; Chestnut Hill low-service, 3.1 cents; Spot Pond, 3.4 cents; Arlington, 12.7 cents; West Roxbury, 21 cents. The average cost at all plants was 3.29 cents.

A large pneumatic tube is under construction in Chicago between the Union Stock Yards postal station and the offices of Armour & Co. This tube is to be approximately one-half mile in length, 20 in. in diameter and will accommodate a carrier holding the contents of an ordinary mail pouch.

Three men were killed by gas in the hold of the wrecked steamer "H. M. Whitney," of the Metropolitan Line, New York to Boston. They had been working on the vessel for a month, raising her from the bottom of Hell Gate Channel, New York Harbor, and had just succeeded. The three men entered the hold to examine it for tightness, but they failed to test the air before they went in, and were overcome before they could be rescued.

What is probably the shortest railroad ever built was put in in Armstrong county, Pa. It is known as the Pittsburg & Northeastern, and is owned by capitalists of Pittsburg opposed to the entrance of the New York Central into that territory. The tracks laid are two rail lengths long, the rails resting on 12 ties laid in the mud. It was necessary that some rail laying be done at once that the charter be kept alive. The new line claims to have the New York Central blocked from Pittsburg.

"Blowing up" is one of the accidents to which deep-water divers are most liable. When a diver is crawling on the bottom with his head down, air may accumulate in the back of his suit, and, getting to his legs, cause him to turn turtle and shoot helplessly upward, with the risk of coming into contact with a ship's or boat's bottom. To prevent such accidents the diving committee of the English Admirality has recommended that all new diving suits be provided with an arrangement for lacing up the legs and thighs.

A Vacuum Cesspool Exhauster in which the vacuum is created by a steam-ejector has been placed in service by the Epsom, England, Rural District Council. The vacuum tank, which has a capacity of 750 gal., is made of galvanized steel and is fitted with vacuum and level gauges. After the vacuum has been created the inlet pipe is put down into the cesspool and the valve opened, allowed the sewage to be drawn into the tank. The tank is mounted on a self-propelled truck containing a quick-steaming boiler. The traction gearing allows of speeds of one to five miles an hour.

An overlooked factory danger has been pointed out in Germany by Prof. M. M. Richter, who has found that machinery belts—especially in dry air and when rubbed with resinous substances—may become highly charged with electricity, and may give off sparks that, in an atmosphere laden with dust or combustible vapors, may produce a serious explosion. A five-inch belt running over a wheel making 600 to 2,000 revolutions a minute gave off a spark one to one and a half inches long. Coating the belts with bronze or aluminum powder proved an ineffective preventive, but acid-free glycerin, applied once a week, attracted moisture, and not only gave security against static charges, but increased the life of the leather.

In the construction of the Bank of Commerce Building at St. Louis some important problems of engineering were encountered. The discovery of quicksand underneath the site necessitated resort to compressed-air caisson work, with the result that the caissons, and consequently the foundations, have been sunk to solid rock, ranging from 60 to 70 feet below the street level. During this work it was necessary to put nine caissons under the south wall of the building on the north, within which heavy machinery closely placed made the work doubly difficult, though it was accomplished without the slightest damage to either the contents or wall of the structure. The latter has not settled a particle, though the deep boiler-rooms of the adjoining structures to the north and east had to be upheld during the process. In the course of this work the vault foundations were placed for the bank, being heavy monoliths of reinforced concrete reaching nearly 20 feet below the floor of the basement of the bank. These rest on caissons, and the vaults when completed will be three stories high. They will be enclosed in the walls, running 12 feet below the water level of the city, and, through the caissons, will rest on solid rock.

Lime cartridges are often used in Europe in powderless coal mining. Pure carbonate of lime ground to a fine powder is made up into a cartridge 3 to 4½ in. long with a groove ½ in. in diameter on one side. An iron tube ½ in. in diameter, and perforated on the upper side, is inserted the whole length of the bore hole. This tube is inclosed in a calico bag which covers the perforations and one end of the tube, the other end is fitted out with a tap. The cartridges are then pushed to the back of the hole drilled for them and tamped as if they were gun powder. A small force pump is connected with the tap at the end of the tube by means of a short flexible pipe, and water equal in bulk to the quantity of lime used, is forced in. The water escapes through the perforations as it passes along the groove and the lime in the cartridge is saturated, the tap is closed steam is generated and the combination of generating steam and expanding lime brings down the coal.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JULY 7.

892,426. AIR-SANDER. WILLIAM HUGHES, Beaver Meadows, Pa.

892450. PRESSURE - REDUCING VALVE. THOMAS ROBINSON, Low Bentham, England.

892,561. AUTOMATIC AIR-BRAKE-PRESSURE ADJUSTER. ULYSSES S. SMITH, Sacramento, Cal.

892,573. ACETYLENE-GAS GENERATOR. CHARLES W. BECK, New York, N. Y.

892,772. HYDRAULIC AIR-COMPRESSOR. CHARLES H. TAYLOR, Westmount, Quebec, Canada.

892,849. DRILLING-MACHINE. TUNNEL BORING MACHINE. JOHN P. KARNS, Boulder, Colo.

892,887. PNEUMATIC PIANO-PLAYER. CLARENCE E. PRYOR, Binghamton, N. Y.

892,955. APPARATUS FOR GAS ANALYSIS. CARL A. HARTUNG, Berlin, Germany.

JULY 14.

892,974. AIR-PUMP. GEORGE P. ABORN, Boston, Mass.

1. A pump having a cylinder of two diameters, the upper larger portion forming an air cylinder and the lower smaller portion a water cylinder, upper and lower passages for admitting air and water to the air cylinder, a plunger in the air cylinder acting to open the air passage on its down stroke and the water passage on its up stroke for the admission of air and water, and to deliver air on the up stroke, and a smaller plunger for delivering water from the water cylinder on the down stroke.

893,000. VACUUM CLAMPING DEVICE FOR STAVE COLUMNS. GEORGE W. LOGGIE, Bellingham, Wash.

1. A vacuum clamping device used in manufacturing stave columns in which is combined means for holding a number of staves assembled in columnar form; means for hermetically sealing the ends of said stave columns; and means for exhausting the air from within said stave columns.

893,033. AUTOMATIC SPRINKLER APPARATUS. EVERETT L. THOMPSON, Dover, N. J.

893,038. AIR-PUMP FOR INFLATING PNEUMATIC TIRES. OCTAVE VADAM, Paris, France.

893,049. VENTILATING TUNNELS. HENRY BLACKMAN, New York, N. Y.

893,052. WINDMILL. JOHN A. CARLSON, Chicago, Ill.

893,101. CAN-TESTING MACHINE. FRANK RUDOLPHI, Chicago, and CHARLES J. NELSON, Maywood, Ill.

893,138. PNEUMATIC TOOL. HERBERT A. BROCKWAY, Denver, Colo.

893,192. HIGH-PRESSURE GAS-PRODUCER. EDWARD P. NOYES, Winchester, and SIDNEY A. REEVE, Worcester, Mass.

893,222. HYDRAULIC AIR-COMPRESSOR. PETER BERNSTEIN, Mulheim-on-the-Rhine, Germany.

893,261. VALVE MECHANISM FOR AIR-BRAKE APPARATUS. FRANKLIN A. PIERCE, Wheeling, W. Va.

893,296. PNEUMATIC IMPACT - TOOL. GEORGE L. BADGER, Quincy, Mass.

893,393. MEANS FOR CONTROLLING THE STROKE OF FLUID-OPERATED PISTONS. JOSEPH W. SMITH, Portland, Oreg.

JULY 21.

893,599. HYDROCARBON-BURNER. JOHN F. BARKER, Springfield, Mass.

1. In a hydro-carbon burner having in combination, a main body portion, a diaphragm dividing the same into two chambers, a barrel portion connected with the main body portion, a spider provided with passage-ways and communicating with one of said chambers, nozzles communicating with the passage-ways of the spider, and a plate provided with conical shaped openings carried by the barrel and into which the nozzles project, whereby upon the passage of the hydro-carbon liquid through the nozzles and atmospheric air under pressure through the conical-shaped openings in the plate, the liquid fuel will be atomized, as described.

893,605. WARNING-SIGNAL FOR AIR-BRAKE SYSTEMS. BENJAMIN BRILL, Jr., North Bay, Ontario, Canada.

893,614. ANGLE-COCK FOR AIR-BRAKE SYSTEMS. JAMES FALLON, North Bay, Ontario, Canada.

893,710. AUTOPNEUMATIC MUSIC-PLAYING INSTRUMENT. WALTER R. CRIPPEN, Cambridge, Mass.

893,712. STARTING DEVICE FOR EXPLOSIVE-ENGINES. JULIAN F. DENISON, New Haven, Conn.

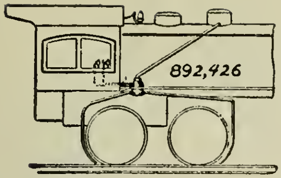
893,733. AUTOMATIC APPARATUS FOR SUPPLYING AIR FOR MANY PURPOSES. WILLIAM HOOKER, South Melbourne, Victoria, Australia.

893,851. AIR-VALVE FOR AIR-COMPRESSORS. JOHN G. LEYNER, Denver, Colo.

893,852. AIR-VALVE FOR AIR-COMPRESSORS. JOHN G. LEYNER, Denver, Colo.

893,854. SUCTION APPARATUS FOR PENUMATIC CLEANING SYSTEMS. WILLIAM LOCKE, Westfield, and ELIAS B. DUNN, East Orange, N. J.

893,899. MOTOR OPERATED BY LIQUE-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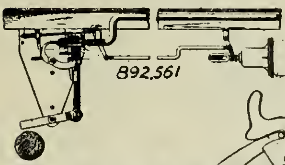
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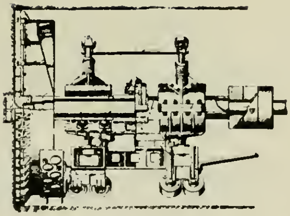
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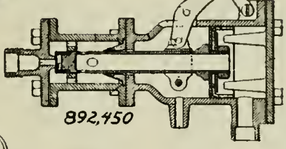
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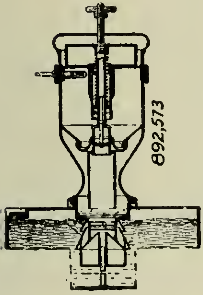
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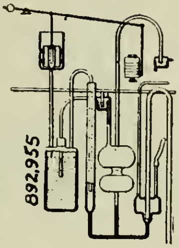
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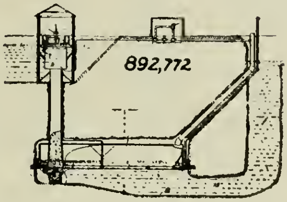
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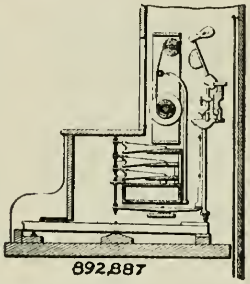

892,887

Pneumatic Patents, July 7.

FIED CARBON DIOXID. Georges Brousseau, Agen, France.

893,913. FLUID-COMPRESSOR. Frank Felbinger, Milwaukee, Wis., and Alexander E. Cafmeyer, Chicago.

894,018. AUTOMATIC PRESSURE-CONTROLLING DEVICE. William F. Krichbaum, Newark, N. J.

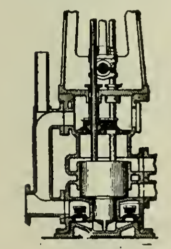
894,031. AIR AND LIKE PUMP. Donald B. Morison, Hartlepool, England.

894,047. GAS-ACTUATED BLOWING-ENGINE OR COMPRESSOR. Gustav B. Petsche, Phialdelphia, Pa.

894,048. BLOWING-ENGINE OR COMPRESSOR. Gustav B. Petsche, Philadelphia, Pa.

894,056. AQUARIUM ATTACHMENT. Henry A. Rogers, Pagosa Junction, Colo.

The combination with an aquarium tank, of a stand pipe secured to the bottom of the tank, and communicated with the tank through an opening near the bottom of the pipe, said pipe having a plurality of chambers at its top, the chambers communicating with each other and with said opening of the stand pipe, a substantially horizontal pipe leading from one of said chambers and discharging into the tank above the level of the water therein, a pipe leading from the other chamber outside of the aquarium, means connected with the last named pipe for supplying air to the stand pipe. and a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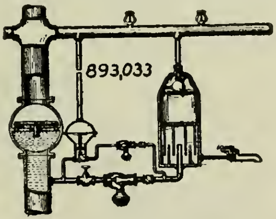
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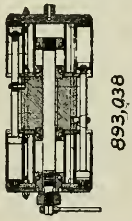
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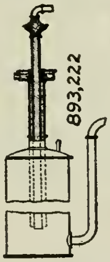
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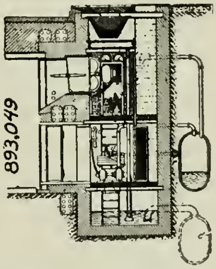
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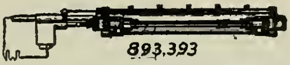
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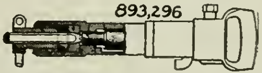
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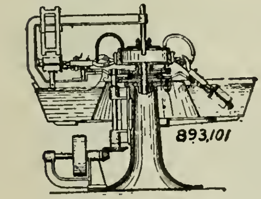
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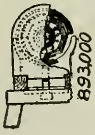
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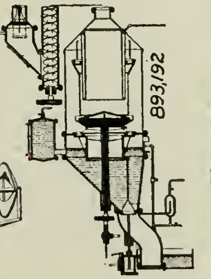
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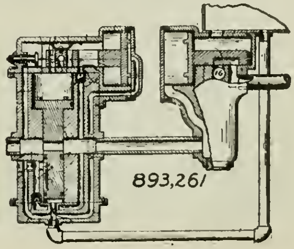
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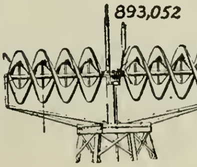
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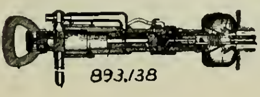
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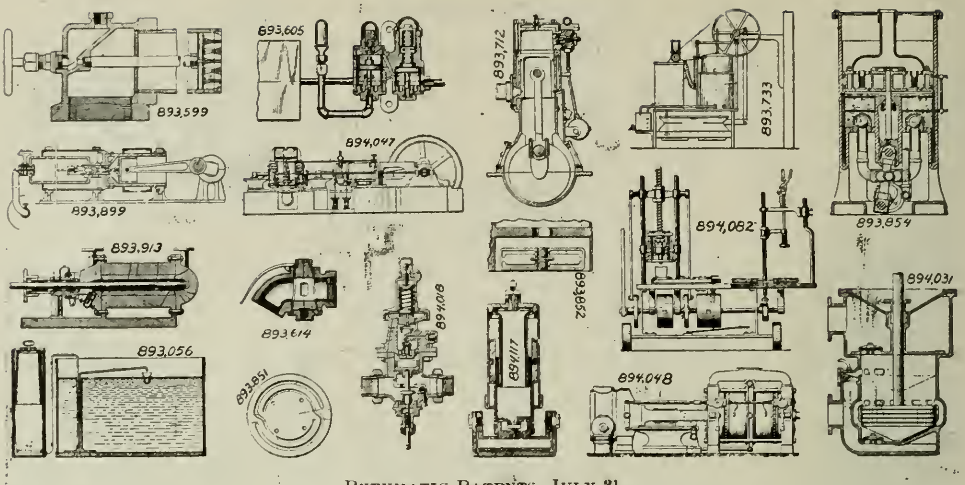
Pneumatic Patents, July 14.



Pneumatic Patents, July 21

strainer below the open end of the horizontal pipe.

894,082. GLASS-BLOWING MACHINE. William S. Teeple, Wellsburg, W. Va.

894,117. PNEUMATIC SUSPENSION MEANS. James H. Clark, Richmond, Va.

JULY 28.

894,204. RAILWAY SAFETY APPLIANCE. Michael E. Hogan, Chicago, Ill.

894,213. ROCK-DRILL. Henry J. C. Keymer, Gorleston, Great Yarmouth, England.

894,272. SAND-BLAST APPARATUS. Albert Jorn, Jr., Waukegan, Ill.

894,280. ENGINEER'S VALVE FOR COMPRESSED - AIR - OPERATED DUMP-CARS. Thomas R. McKnight, Aurora, Ill.

894,493. PNEUMATIC CUSHION FOR VEHICLES. Edward A. Garvey and Christopher A. Garvey, St. Louis, Mo.

894,546. PNEUMATIC-ACTION FOR MUSICAL INSTRUMENTS. Edward A. Steel, Detroit, Mich.

894,586. PNEUMATIC PUMP. Albert Brest, New Castle, Pa.

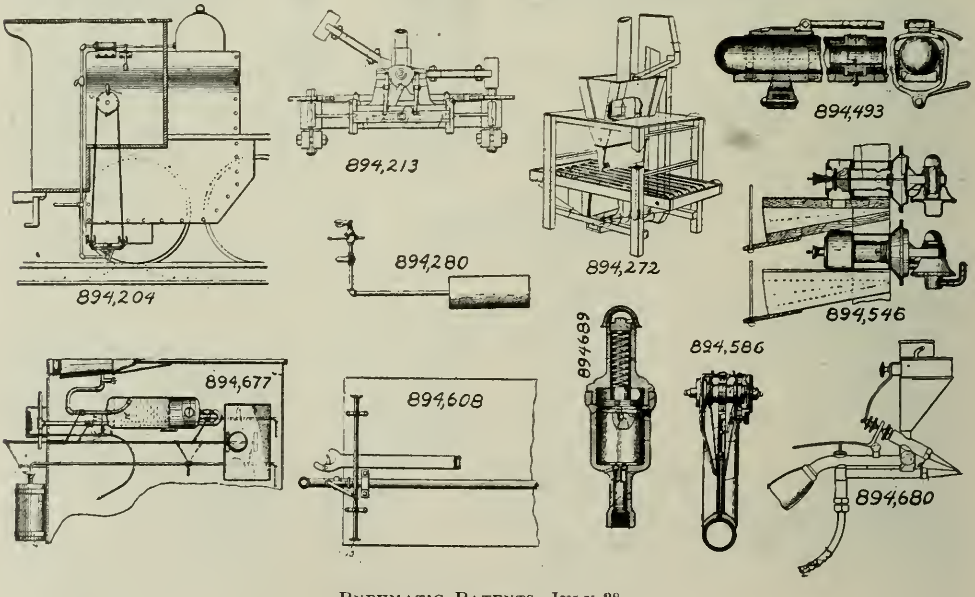
894,608. AIR-BRAKE SYSTEM. William T. Crumpler and Joseph L. Crisler, Pittsburg, Kans.

894,677. FIRE-EXTINGUISHER. Norris P. Matlock, Chickasha, Okla.

1. In a device of the class described, a reservoir containing a fire extinguisher liquid and normally communicating with the main pipe of the air brake system, whereby said reservoir is maintained at all times under air pressure said reservoir having a normally closed outlet.

894,680. PAINT-SPRAYER. Hans Mikorey, Schoneberg, near Berlin, Germany.

894,689. AUTOMATIC PRESSURE-RETAINING VALVE FOR AIR-BRAKE SYSTEMS. James D. Nichol, Finley, Wash.



Pneumatic Patents, July 28.

COMPRESSED AIR
MAGAZINE
EVERYTHING PNEUMATIC.

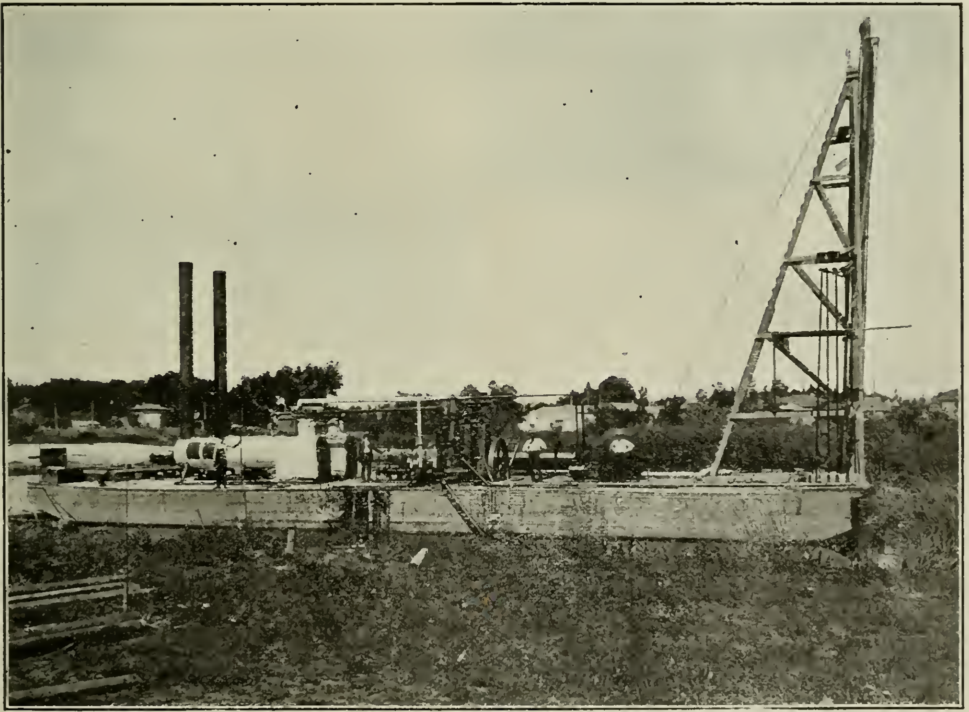
Vol. XIII OCTOBER, 1908 No. 10

A NOVEL PNEUMATIC DREDGE

California is the land of the gigantic in many things, not the least, perhaps, of which are its dredging problems, which in both character and magnitude challenge the resources of the modern engineer. Dredging has been carried on extensively for a generation and has developed high efficiency and adaptability under the exacting requirements.

Immense deposits of silt have accumulated, largely due to hydraulic mining operations near the head water of the streams, the flood carrying capacities of the channels, originally inadequate, have been greatly reduced and many miles of waterway require to be widened and deepened, the work entailing also the reclamation of over a million acres of fertile lowlands. Hundreds of millions of cubic yards of material must be removed to restore normal conditions or to secure more desirable locations, and the values so created or restored will warrant enormous expenditures.

The general character of the work involved



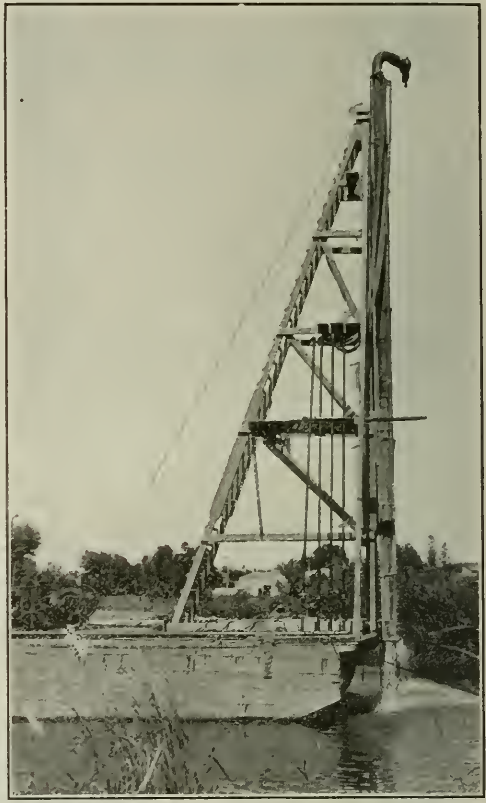
A NOVEL PNEUMATIC DREDGE. LIFTS SAND FROM UNDER 28 FEET OF CLAY.

is not only the lifting of the submerged material but also its conveyance to a considerable distance from the lines of excavation, for the forming of levees which shall give sufficient water areas and restrain future encroachments of either element upon the other. The clam shell and dipper dredges have been extensively used but neither has sufficient reach to deposit the material as required. The efficiency of the hydraulic dredge is recognized, but it is costly to instal, to operate and to maintain, and no satisfactory and economical system has been found until the advent of the pneumatic dredge with its special ability in the hoisting and conveying of sand and other loose material mixed with water.

Great interest is felt in the installation which we here illustrate. It not only demonstrates its high efficiency and cheap rate of working for the general line of service required in this region, but in this case in addition it adapts itself to a special condition of working which all other known devices were compelled to decline. This dredge is now working upon its second contract for the City of Sacramento. The work upon which it is employed is the excavating of a lake and the filling of the adjacent low grounds with the material for the formation of a public park. Although it was required to fill in a large surrounding area the proposition was not an unusual one and seems quite simple in the telling of it. The material to be excavated, however, was found to be a stiff clay, which none of the usual dredging apparatus could handle, and not a bid was received for the work.

It was found that the stratum of clay had a nearly uniform thickness of 28 feet and under this was sand of unknown depth. The operation of excavating for the proposed lake as actually carried on consists in *taking out the sand from under the clay,* and allowing the latter to settle down, giving the depth of water required. This is done cheaply and rapidly by the pneumatic dredge shown in the half tone, Fig. 1. Not only is the sand raised as required but it is discharged at various distances up to 1,500 feet in any direction from the excavating pipe, thus distributing over a large area and bringing the surface to a predetermined level.

The principle of operation of this dredge is that of the now familiar air-lift pump, and all the conditions essential to the successful operation of this device are present. A most imperative condition is a sufficient submergence, and this the nature of the work itself provides. In the case of the clamshell or the dipper dredge a great unbalanced weight of dipper and appurtenances, greater than the load of sand itself, has to be lifted every time, thus more than doubling the power required. In the case of the air lift as here employed there is little more than the pipe friction to be overcome until the surface of the water is reached, and the principal work is in the lifting of the material to the height above the water level required for the discharge. This sufficiently accounts for the high comparative economy realized by the apparatus.



EDUCTION PIPE RAISED.

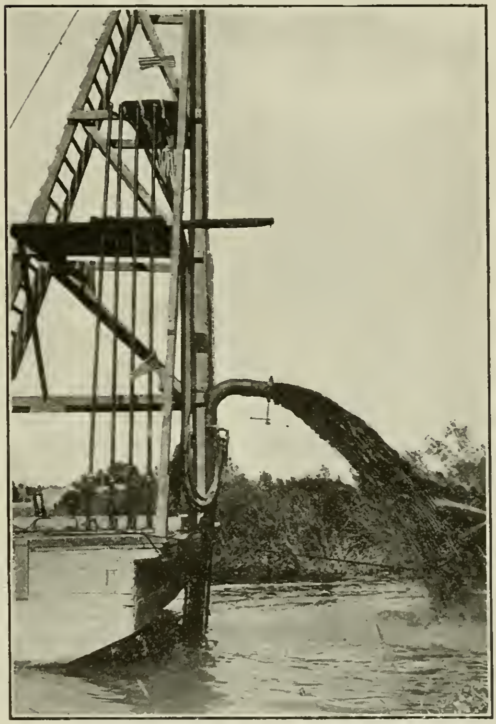
On the scow or barge as shown there are two locomotive boilers, using oil for fuel, an air compressor, two steam pumps for water, a hoist and an A frame with vertical guides for the eduction pipe. This pipe, 10 inches in diameter and 50 feet long is provided with a "head" on the lower end about four feet long and eighteen inches in diameter, containing sufficient openings to admit a plentiful supply of water, sand, mud, etc., when in operation. Two inch air and water pipes plentifully supply the head with air and water. These are carried in iron pipes to about one half the height of the A frame, and the hose provides a constant connection whether the eduction pipe is up or down. The air is the lifting force and water is used only for the sinking of the pipe and to dilute or stir up the sand to a suitable consistency for transmission through the discharge line.

For sinking through the clay the pipe is raised and dropped like a pile driver ram, the water keeping the head clear, and when the clay is passed through the sand begins to be brought up at once. Fig. 2 shows the pipe raised to the top of the A frame and its lower end clear of the water. Fig. 3 shows the pipe down to its sand lifting position and gives an idea of the character of the discharge. Pipes are still to be coupled to the nozzel to deliver the sand at a distance. This pipe should be level or descending all the way from the lift, and spiral piping gives the best results.

Owing to the high percentage of solid matter—sand, silt or gravel—raised it was found that the horizontal transmission for long distances might present insurmountable difficulties; but trial has demonstrated that there is no trouble in forcing the water and sand with the original pressure, this pressure being slightly greater than required by the hydrostatic head at the submerged depth. In free moving sand, silt, muck, etc., the per centage of solid matter discharged ranges from 25 to 50 per cent. In the operation of the dredge here shown about 750 cubic feet of free air per minute was required at a gage pressure of 20 to 25 pounds. Three men did all the work of the shift and with two shifts from 1,200 to 2,000 cubic yards, were delivered per day.

It is suggested as an important advantage of the pneumatic system of dredging that a dozen or more dredges could be operated from a central compressing plant. In this case no boiler or fuel would be required upon the barges, as pumps, hoists and all would be air driven.

Mr. M. A. Nurse, for twelve years State Engineer of California, says: "I feel assured from, my wide experience in dredging and reclamation work in the State of California, that the pneumatic dredge is the simplest and most economical method of handling all forms of sand, silt, muck, clinkers, gravel and sedimentary deposits which can be loosened by the action of a hydraulic jet. Sedimentary deposits can be raised from any depth below the water level and transported several hundred feet with one operation and at a cost which will allow the device to compete with any other dredging machine now in use. Where gold values are found in sedimentary soil the pneumatic dredge will prove a very efficient device for gold dredging. It will operate in many cases where the ordinary bucket dredge is useless."



DISCHARGE OF SAND AND WATER.

For the photos and the information contained in this article we are indebted to Mr. Elmer E. Corey, of Sacramento.

WOOD PRESERVING PROCESSES

A Primer of Wood Preservation, Forest Service Circular No. 139, is an interesting and important addition to the list of pamphlets issued by the Department of Agriculture for the dissemination of practical information bearing upon our industries and resources.

In the United States creosote and zinc chlorid are the only preservatives in common use. Just as there are two preservatives in common use, so there are two principal methods in injecting them into the timber. These may be called the "pressure-cylinder method" and the "open-tank method." A third process, known as the "brush method," is used to a more limited extent.

THE PRESSURE PROCESS.

Up to very recent times the pressure-cylinder method was used almost exclusively in the United States. With creosote it is known as the Bethell process, and with zinc chlorid the name of Burnettizing is applied. The timber to be treated is placed on iron trucks or "cylinder-buggies" and drawn by steel cables into huge horizontal cylinders, some of which are 8 or even 9 feet in diameter and more than 150 feet long. These are capable of withstanding high pressure, and their doors are so arranged that, after the timber is drawn in, they can be closed and heremetically sealed. It is the common practice in this country—a practice with long experience in Europe, as well as in America, has proved to be unwise—to treat the timber before it has had time to dry out in the open air. The following is the usual method. After the doors are closed live steam is admitted into the cylinder, and a pressure of about 20 pounds per square inch is maintained for several hours, the exact time depending upon the individual opinion of the operator, as well as upon the moisture content and size of the timber under treatment. In some cases the steam pressure is allowed to go considerably above 20 pounds, but there is constant risk of injurying the strength of the timber. When the steam is at last blown out of the cylinder, the vacuum pumps are started and as much of the air as possible is exhausted from the cylinder and from the wood structure. This process also continues for several hours. Finally, after the completion of the vacuum period, the preservative is run into the cylinder and the pressure pumps are started and continued until the desired amount of preservative fluid is forced into the wood. The surplus preservative is then blown back into the storage tanks, the timber is allowed to drip for a few minutes, and finally the cylinder doors are opened and the treated timber is withdrawn.

THE OPEN-TANK PROCESS.

The injection of the preservative by the open-tank process depends upon a different principle. The wood is first thoroughly seasoned, and much of the moisture in the cells and intercellular spaces is replaced by air. If the timber is peeled soon after cutting, and stacked in open piles, the time required for seasoning can be greatly lessened. The seasoned timber, or that portion of it which is to be preserved, is immersed in a hot bath of the preservative contained in an open iron tank. This hot bath is continued for from one to five or six hours, depending upon the timber. During this portion of the treatment the air and moisture in the wood expand and a portion of them pass out, appearing as little bubbles on the surface of the fluid. At the end of the hot bath, as quick a change as possible is made from the hot to a cold preservative. This causes a contraction of the air and moisture remaining in the wood, and, since a portion of it has been expelled, a partial vacuum is created which can be destroyed only by the entrance of the preservative. Thus atmospheric pressure accomplishes that for which artificial pressure is needed in most of the commercial plants. Whether the open-tank or pressure-cylinder method is the more desirable depends upon the particular conditions of each case. Both methods have their particular uses and neither can always be wholly substituted for the other.

Still there are some architects who are so far behind the times that they do not know stone can be had cheaper than face brick in many of the markets. Time was when cut stone was very costly, and so it is generally considered, but with the improvement of equipment for the cutting shed as well as the quarry [pneumatic tools especially, Ed. C. A.] this is no longer the case. Richest carving and even elaborate designing is now in the reach of moderate building appropriations.—*Rock Products.*

GOLD MINING AS A NON-SPECULATIVE BUSINESS AND AN EXACT SCIENCE

William L. Saunders, President of the Ingersoll-Rand Compnay, is reported as follows by an interviewer in the *Wall Street Summary*:

"The gold mining interest is establishing new high records of production at low costs of operation. The numerous remarkable inventions, discoveries and improvements in mining which have marked recent years enable operators to extract more gold per ton of ore and at considerably lower costs. These inventions and discoveries and the many improvements in the administration of mines have practically added billions of dollars to the estimated valuations of our mines of the various metals. Gold, silver and copper ores which, a few years ago, were regarded as not worth working, are now eagerly sought for by the refining interests. Mining is somewhat like farming, in that it is a business that can always find quick cash markets for its products. The mining interests of this country have saved all of us from what looked like a long period of commercial depression, as the most sagacious financiers saw the business prospect last year. Our gold production has exerted a most powerful energy in the uplift of the industries of the whole country.

"The gold production in the United States for this year will go well above the $100,000,000 mark. A few years ago, the best informed gold miners did not consider it within reason to predict an output of that amount before 1915. Notwithstanding the enormous expansion in the world's production of gold, there is an ever growing demand for it, and the price year after year is steady at the value of a fraction more than $20 per fine ounce.

Within a short time I was with a party of engineers and manufacturers who visited a number of gold mines. We saw at one camp gold ore in sight to the value of $30,000,000. At other camps in that region we saw almost as large visible supplies. The quickening of business, which is happily going on throughout our land, is in great part due to the tremendous energies of our mine operators, who kept right on developing and marketing products despite the stormy financial skies of last year. Those men who kept right on adding enormously to the resources of the country demonstrated practical patriotism that everybody ought to appreciate.

"Our rapid advance in gold output began in 1892. There was a temporary setback from 1901 until 1904, when the increase in gold production was $7,000,000 more than the previous year. When silver mining was hard hit a few years ago, croakers said that the silver interests was almost destroyed. But the silver mine operators were made of sterling metal. They went right ahead and engaged in gold and copper mining. In the case of Colorado, where years ago the silver interest was far and away the largest, the transfer of energies to gold has made her gold worth much more than her silver mining interest.

Silver mining has a great future. The great silver using countries are making forward strides in population and in increase of the purchasing power of units of population. The expansion of gold production is helping the silver, copper, lead, iron and other mining industries; and, in fact, is stimulating the increase of the material well being of people in all lands. Our gold mines' ever increasing production is a powerful factor in placing us high for credit in foreign money markets. Increasing gold production has forever laid to rest that vexatious question which, under various guises, pledged us for years under the common name of the two metals currency question. But for our great showing as owners and operators of gold mines, we could not have gone ahead and adopted the gold standard, which helped us in the borrowing of the immense amounts of money abroad that have been put to profitable use in developing resources that are worth billions to us. Mexico, a great silver producing country, adopted the gold standard chiefly to advance her credit abroad. That object was accomplished in such volume as to place her far forward in the ranks of Nations that are highly prosperous.

"It is remarkable that in a community like New York, which is most largely engaged in ordinary merchandizing at very small profits, there are so many men who regard mining as a speculative business. Mining is an exact science devoted to strictly commercial ends, and it is by far the most profitable business in the world. Speculation is a very small factor in mining. No other interest has paid; or, is likely to pay, so well upon the capital invested as legitimate mining. Compare the results from investments in railroads for many years with the annals of sound mining, and it is easy to see that railroading, in comparison with mining, may be termed a speculative pursuit, whereas mining has made a record that places it among the steadiest dividend-earners known in modern times. Mining is on the eve of a great forward movement of mine improvement. So far as I know, there is not likely to be a setback in the recent improvement in the market for mining machinery.

"Iron cloth" is now used by American tailors for stiffening collars, etc. It is manufactured from steel wool, and looks like horsehair.

OXY-ACETYLENE WELDING AND CUTTING*

The highest temperature of the best solid fuel furnaces is about 3,000 F. The oxy-hydrogen, which was the hottest of the gas flames, is something less than 4,000 F. The oxy-acetylene flame jumps this temperature more than 2,000 F. to about 6,300 F., being more than double the hottest solid fuel heat known. As acetylene produces about five times more heat per cubic foot than hydrogen, and nearly doubles it in intensity, a marvelously powerful flame is condensed into very small volume. Compared to the oxy-hydrogen flame, it is like a finely-pointed tool to a blunt instrument. With such a tool, having heating power from two to three times that required to melt the commercial metals, almost increditable results are obtained. Steel, cast iron, aluminum, brass, copper and other metals can be so perfectly united that when smooth the joint cannot be discerned. Containers for fluids and liquids can be made without joints, and will not leak when bruised or dented. Blow-holes and other defects in iron, steel, brass and other castings can be repaired, not only saving the castings, but many times expensive machine work as well. Quickly repairing broken machines, boilers and steam and other piping in place is one of the most valuable features of this process. Worn parts of machinery and teeth on gear wheels can be built up; tool steel added to common steel; dies repaired, and numberless other operations accomplished which are not possible by other methods. Not only similar metals but those of different kinds can be perfectly united.

The facility with which steel and iron (except cast iron) can be cut is really marvelous. The operation is performed by heating the metal at the first point of contact to the red by the ordinary welding flame, and with this flame continued, a jet of pure oxygen is turned on which unites with the carbon of the metal and disintegrates it with surprising rapidity. The cut is narrow and smooth, with no material injury by oxidation. The cut can be made in any shape, and the process will be found very useful in cutting irregular forms, and will be valuable, especially in making many kinds of dies and in fitting steel plates. It is very effective for cutting steel beams in structural work.

The A. Boas, Rodrigues & Co. torch, known here as the Davis-Bournonville, has been improved in design and construction until it is now practically perfect. All of the authorities have given 2.5 parts of oxygen to 1 of acetylene, as the theoretical quantities required, and 1.8 of oxygen to 1 of acetylene, as the quantities actually used in practice. With their apparatus and torch the Davis-Bournonville Co. has succeeded in securing a perfect welding flame, with only 1.28 parts of oxygen to 1 of acetylene, not only effecting a very material saving in the cost of operation, but obtaining better results as well. An imperfect mixture of gases is not only much more expensive, but an excess of oxygen oxidizes the metal, and too much acetylene carburets it, either condition being seriously detrimental.

The table on the opposite page, showing the approximate cost of cutting and welding will be of interest to investigators.

It is stated that the Georgia Marble Company, Tate, Ga., throughout the recent prevailing slackness did not lay off any men nor cut their wages.

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*From a paper by Augustus Davis before the Chicago meeting of the International Acetylene Association.

APROXIMATE COST OF OXY-ACETYLENE WELDING.

Oxygen at three cents—Acetylene at one cent per cubic foot. Labor 30 cents per hour.

Tip Number	Thickness of Metal	Consumption of Acetylene Per Hour	Consumption of Oxygen Per Hour	Proper Pressure in Pounds for Oxygen	Lineal Feet Welded Per Hour	Cost of Labor Per Hour	Total Cost Per Hour	Cost Per Lineal Foot
1	1/32 to 1/16	2.8 feet	3.6 feet	8 to 10 lbs.	50 feet	.30 cents	.436	.0087
2	1/16 to 3/32	4.5 "	5.7	10 to 12 "	30 "	30 "	.516	.0172
3	3/32 to 1/8	7.5 "	9.7 "	12 to 14 "	25 "	30 "	.666	0266
4	1/8 to 1/4	11.7 "	15. "	14 to 18 "	16 "	.30 "	.867	.054
5	1/4 to 5/16	18. "	23. "	18 to 22 "	10 "	.30 "	1.17	.117
6	5/16 to 7/16	25. "	32. "	20 to 25 "	7 "	.30 "	1.51	.216
7	7/16 to ½	32.5 "	41.5 "	22 to 27 "	5 "	.30 "	1.87	.374
8	½ upward	48.5 "	62. "	24 to 30 "			2.64	

APPROXIMATE COST OF CUTTING STEEL.

Number Cutting Tip	Use Welding Tip No.	Thickness of Steel	Heating Jet. Feet of Acetylene	Heating Jet. Feet of Oxygen	Cutting Jet. Feet of Oxygen	Pressure of Oxygen Heating Jet	Pressure of Oxygen Cutting Jet	Lineal Feet Cut Per Hour	Labor Per Hour	Total Cost Per Hour	Cost Per Lineal Foot
1	4	up to ½"	12	15½	60	14 to 18 lbs.	125 lbs.	60	.30	2.68	.0447
2	4	½" to 1½"	12	15½	75	14 to 18 "	125 to 150	50	.30	3.13	.0627
3	5	1½" up	18	23	75	18 to 22 "	150 to 175	40	.30	4.02	.1005

FUEL COST OF POWER AIR HAMMERS

The use of compressed air for driving hammers in blacksmith shops, boiler shops, etc., where steam has usually been employed, is rapidly extending, especially in Great Britain, and information concerning the cost and other conditions of operation is welcome. The following letter to *The Engineer*, London, is from Mr. T. Scott King and it speaks with indisputable authority concerning the performance of the N. S. K. hammer of which the writer is a joint inventor. The results as given in the tables shown are actual saving in power cost when operating with air, and the other accompanying advantages should make the air service extremely desirable for this purpose. The letter follows:

SIR:—The article on "Steam *vs* Compressed Air" in your issue of April 17th last [see *Compressed Air* for July, page 4937] based on results tabulated in Messrs. B. and S. Massey's steam hammer catalogue, assumes that as there is no gain in working expansively in steam hammer cylinders, the same holds good of hammers using compressed air, and under these conditions proceeds to demonstrate that the fuel cost of operating steam hammers is less than buying electrical energy to compress air, whereas in the N. S. K.—Norris and Scott King—compound pneumatic hammer manufactured by Messrs. Peter Pilkington, Limited, Bamber Bridge, near Preston, compressed air is expanded to three or more volumes, resulting in an economy of 50 per cent. in the size of compressors and driving power.

It is not necessary to refer to the construction of this hammer except to state that air under pressure is admitted to the fixed space formed under the tup piston when raised to its highest working position. The inlet port to the striking piston is then opened and the air flows from the underside, and acting on the larger area is expanded in accelerating the falling tup. Reference to Tables, I and II. will show that in 1,000 strokes the 5 cwt. steam hammer has a displacement to atmosphere of 1,258 cubic feet, as compared with 861 cubic feet displacement on an equal size N. S. K. compressed air hammer. In the Massey statement, steam pipe condensation is allowed for, but cylinder losses are ignored, and, being the greater, vitiate the economy claimed for the steam hammer to a very serious degree.

Economy in the use of steam in cylinders is to be obtained by constant running at high speeds with small clearances, reducing the masses of metal and radiating surfaces to a minimum, superheating the steam and using a high ratio of expansion. It is wisely stated in your article that only very slight expansive working is possible in steam hammer cylinders, for undoubtedly the steam hammer is working under best conditions when admitting steam at full pressure to the striking cylinder. The every day working conditions of a smithy hammer are dead against steam economy, for the power agent depends for its efficiency upon the maintenance of a high temperature, whereas the work is intermittent, leading to condensation in the conveying pipes and great liquefaction in cold cylinders. And, further, there is no hope of improving the economy of steam hammers, for compounding and superheating add complications without compensating gain. There is one feature of great loss in striking dead or maximum blows non-expansively, viz., that during the fall of the tup at high velocity, the air or steam usually conveyed in lengthy pipes cannot maintain the full pressure in the striking cylinder, and consequently there is a considerable "drop" between the average pressure acting in the striking piston and the pressure in the boiler or air receiver. The trouble, however, does not end here, for when the blow has been struck the air or steam continues to flow into the cylinder until the full pressure is reached, and although the energy of the blow struck is determined by the falling weight and average pressure acting on the piston, an increased pressure is thus afterward admitted to the cylinder uselessly.

TABLE I.—*Fuel Cost of Operating Steam Hammers, Heavy Forge-Type.*

Condition of working	Non-expansively
Nominal catalogue rating	5 cwt.
Diameter of striking piston	9in.
Diameter of piston-rod	5½in.
Area of striking piston	63.62in.
Net lifting area of piston	39.36in.
Stroke of tup, full stroke	1ft. 9in.
Weight of falling mass	560 lb.
Working pressure, gauge	85 lb.
Average pressure on striking piston	50 lb.
Net exhaust displacement to atmosphere of striking and lifting pistons in 1000 full length blows	1258 cub. ft.
Pressure in cylinder when blow has been delivered, gauge	85 lb.
Energy in foot-lb. at moment of impact, 1.75 (63.62 × 50 + 560)	= 6546.75
Net weight of steam exhausted from the striking and lifting cylinders in 1000 full length blows; the cylinder condensation and missing quantity being taken at 100 per cent. to allow for the intermittent character of the work and the constant losses in heating up a cold cylinder, valve chest, &c., $\frac{1258 \times 2}{4.33}$ = lb. of steam	581.4
Evaporative duty being taken at 5 lb. of water per lb. of coal to cover stand by losses on boiler and condensation in pipes $\frac{581.4}{5}$ = lb. of coal necessary to to strike 1000 full length blows	= 116.3
Cost of coal per 1000 blows at 10s. per ton	6.23d.
,, ,, ,, 17s. 6d. per ton	10.9d.
,, ,, ,, 25s. per ton	15.575d.

This loss is entirely avoided by using a fixed ratio of expansion in the N. S. K. compressed air hammer when striking normal blows, and an additional inlet port is provided for striking dead blows, which, under like extraneous conditions, gives 58 lb. per square inch average pressure, against 49.8 lb. per square inch when admitted through the usual single inlet port.

A comparison of Tables I. and II. shows that when supplied with steam at 85 lb. pressure generated with coal at 10s per ton, the 5 cwt. steam hammer costs for fuel three times as much as the N. S. K. compressed air hammer working non-expansively and 5½ times more than the N. S. K. when used expansively doing equal work.

This result is obtained from an engine using producer gas and giving 7½ brake horse-

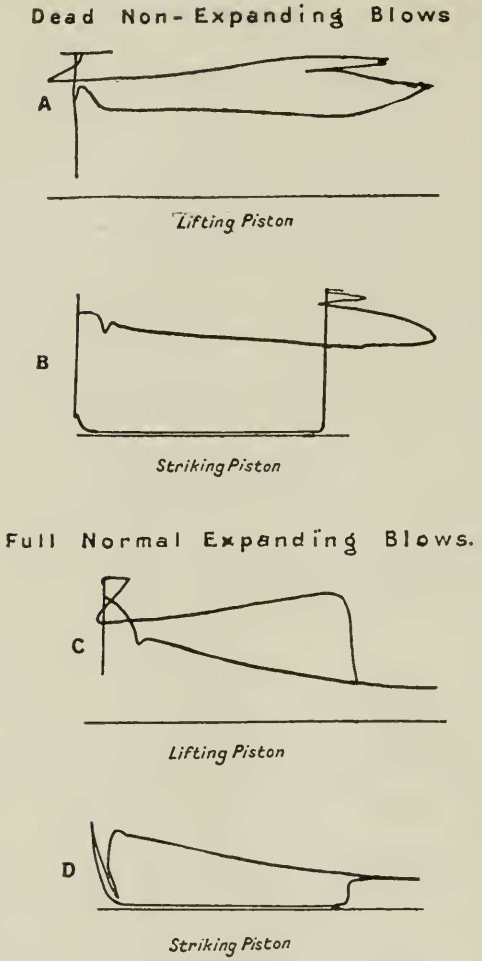
Table II.—*Fuel Cost of Operating N.S.K. Compressed Air Hammers, Heavy Forge Type.*

Conditions of working		Non-expansively	Expansively
Nominal catalogue rating		5 cwt.	5 cwt.
Diameter of striking piston		9½in.	9½in.
Diameter of lower differential piston		7¾in.	7¾in.
Net striking area of piston		47.17in.	47.17in.
Net lifting area of piston		23.71in.	23.71in.
Stroke of tup		1ft. 9in.	1ft. 9in.
Weight of falling mass		791 lb.	791 lb.
Working pressure		85 lb. sq. in.	85 lb. sq. in.
Average pressure in striking piston		58 lb. sq. in.	24 lb. sq. in.
Terminal pressure in striking cylinder after blow has been delivered		85 lb. sq. in.	16 lb. sq. in.
Net displacement of striking cylinder to atmosphere per 1000 full length blows		861 cub. ft.	861 cub. ft.
Net displacement in terms of free air to atmosphere per 1000 full length blows		5740 cub. ft.	1779.4 cub. ft.
Energy in foot-lb. at moment of impact:			
Non-expanding 1.75 (47.17 × 58 + 791)		= 6172 ft-lb.	
Expanding 1.75 (47.17 × 24 + 791)		—	=3365.25 ft.-lb.
Power to compress 6000 cub. ft. of free air per hour to 85 lb. gauge pressure in compound water-cooled cylinders and inter cooler		15.75 B.H.P.	15.75 B.H.P.
Cost of compressing air as above, with producer gas to supply hammers working non-expansively and expansively, as described and corrected for equal work, viz., 6546.5 foot-lb. per blow	No. of B.H.P. for 1d.		
	7½	2.04d.	1.16
	10	1.53d.	.87
	12½	1.224d.	.696
	15	1.02d.	.58
Electrically-driven compressor, 72 per cent. combined efficiency of engin and generator.			
Coal burnt per I.H.P.	2	3	4
Cost of coal per ton	25s.	17s. 6d.	10s.
Index mark	A	B	C
Cost of compressing air as above, with electrically-driven compressor to supply hammer under stated conditions, and corrected for equal work, viz., 1000 – 6546.5 foot-lb. blows	Index mark.		
	A	5.68d.	3.23
	B	6.0d.	3.4
	C	4.54d.	2.58

power for one penny per hour. In taking out fuel costs for electrically-driving compressors, the cheap coal has been allocated to the less economical steam plant and *vice versâ,* for it is assumed that in districts where coal is dear some effort would be made to economise by the use of more improved steam plant.

One thousand full-weight blows with the 5 cwt. steam hammer cost 6.23d., with coal at 10s. per ton, rising to 15.575d., with coal at 25s. per ton, whereas with electrically-driven compressor the N. S. K. hammer will do equal work ranging from 2.58/6d., according as to whether the air is used expansively or non-expansively.

In compiling Tables I. and II., the comparison is based on piston displacements, for the cylinder and port clearances of the air and steam hammers are approximately equal. The comparison is purposely made on fuel costs, for usually the power required intermittently for working hammers is an adjunct to a main power scheme, and the capital and other charges are pertinent to the major rather than to the minor.



7¾"x9½" Cyliners. Nominal 5 Cwt N. S. K.
21" Stroke. Weight of Falling Parts 7c. Oq. 71.
Scale 1-112. Receiver 85 lbs.

The diagrams A and B are taken from 5 cwt. N. S. K. hammer, striking dead blows and using compressed air non-expansively

The diagrams C and D are taken from the same hammer working compound and striking normal full-weight blows for general smith's work. The compressed air is expanded from 100 lb. pressure absolute down to 31 lb. absolute. The rise of pressure will be noted at X on the striking card B and its absence at the terminal of expansion on Card D.

A NOVEL HYDRAULIC AIR COMPRESSOR

To compress air by the direct pressure of water to, say, 85 lbs., gage, which is about the pressure commonly used for operating rock drills and pneumatic tools, requires two hundred foot head for the water. If water with this head were turned directly into a tank full of air it would compress the air and force it out at the required pressure, but it would entail an enormous waste of energy. The volume of water used would be somewhat in excess of the volume of free air compressed. The loss of power would be distributed throughout the operation of compression until the terminal pressure was reached. the losses being greatest at the begining of the compression. To compress the air without this loss of the potential energy of the water it would be necessary that the water pressure should be only sufficient to do the immediate work or to overcome the pressure at the moment.

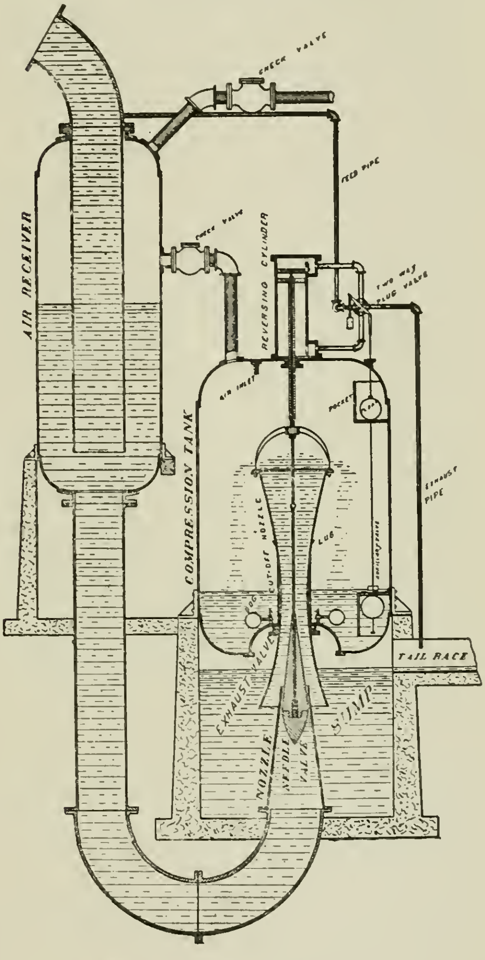
The compression might begin with, say, only a couple pounds of water pressure, this gradually increasing to 16 lbs. when the tank was half full of water. to 46 pounds when it was three quarters full, increasing thence to 86 lbs. when the tank was 85 per cent. full, and then this full water pressure continuing until the compressed air was all expelled into the receiver. The contact of the water with the air may warrant the assumption of isothermal compression, and then the above may be taken as a sketch of the ideal economical employment of water as the agent, and the invention here to be spoken of, the essential feature of which will be understood from the cut, undertakes to approximately adjust the water pressure to the varying resistance by intermingling with the normal supply varying proportions of dead water according to the varying elastic resistance of the air.

This system, for which a U. S. patent has been granted, is the invention of Mr. George C. MacFarlane, Saginaw, Mich., and the description following is mostly furnished by the inventor.

A nozzle or "monitor" connected with a head of water, produced either by gravity or by a turbine pump, is mounted under an air tank. By an arrangement of a shifting cut-off nozzle and a needle valve, the stream issuing from the monitor sluices in enough dead-water from the sump to reduce the velocity head of the stream entering the tank to correspond to the air pressure it must overcome. In the initial stages a small opening of the nozzle sluices in a big stream of dead-water from the sump, in the final stage the needle valve gives a full opening of the nozzle, while the cut off valve shuts off all or nearly all the dead-water. Of course in a case where the water pressure greatly exceeded the air pressure it was desired to maintain, a considerable amount of dead-water would have to be admixed with the live head even in the final stage of compression.

The cut shows the operation of the system when using a gravity water pressure. The pipe head passes down through and nearly to the bottom of the air receiver; from the receiver the water is conducted down a pipe, through a return bend and up into the nozzle, whence it is periodically admitted into the compression chamber. The nozzle is opened and closed by a needle valve, and a vertically moving cut-off nozzle regulates the amount of dead-water admitted with the live head. Both the needle valve and the cut-off are moved up and down by separate pistons operating tandem in one reversing cylinder; their movements being controlled by floats, which operate a two-way plug controlling valve, to admit water above or below these pistons. An exhaust valve for quickly emptying the tank is raised by the upward movement of the cut-off nozzle, the receding water level releases the float-operated dogs and permits the exhaust valve to drop back into place when the tank is nearly empty. The floats that move the controlling valve work in pockets and give a quick reverse to the valve. The cycle of operation is as follows:

Starting with a tank full of air, which the receding water level has drawn in through the inlet ports on top of the tank, the bottom float being down, the controlling valve directs the feed water into the upper port of the reversing cylinder; this shoves both pistons down, lowering the needle valve and cut-off nozzle. As the water flows into the tank, compressing the air, the rising water level raises an auxiliary valve against the drain holes in the upper pocket, and no water can enter the upper pocket until the water level reaches the top of the pocket, when it overflows and quickly throws up the float, reversing the controlling valve, which now directs the feed water into the lower port of the reversing cylinder. Now since the lower piston head rests tight against the lower cylinder head, the force of the water is expended in raising the upper piston, which closes the needle valve; near the end of this up stroke, a dog nut on the needle valve stem engages the bottom of the hollow rod of the lower piston, raising it enough to clear the lower cylinder port.



MAC FARLANE AIR COMPRESSOR.

The lower piston now catches the full water pressure and the cut-off nozzle and the exhaust valve are raised. As the tank empties the receding water level releases the exhaust valve dogs permitting the valve to close; the lower float also drops; reversing the controlling valve, and beginning a new cycle.

Each cycle would require ordinarily about fifteen or twenty seconds to complete, and a nearly constant air pressure would be maintained in the pipe line throughout the cycle by the water level in the air receiver rising and falling. When a charge of air was shoved in to the receiver from the compressing tank, the water level would be lowered; then as the air flowed into the pipe line, water from the pressure main would flow into the air receiver, thereby maintaining a nearly constant air pressure.

It will be seen that this compressor is simple and compact in design and should be constructed and installed at a comparatively low cost per unit; it also possesses the advantage of high mechanical efficiency. The smooth lines of nozzle and cut-off offer very little frictional resistance to the inrushing water, very little energy is needed to actuate the valve and cut-off, and a relatively small amount of the total energy is lost in the inertia of the water discharged from the tank.

While the special field of this system is direct compression from natural heads of two hundred feet and over; it can also be used advantageously in conjunction with an artificial head produced by a multi-stage turbine pump, and the inventor suggests that where the prime mover is a steam or water turbine, an electric motor, or a line shaft, it will often be more convenient and economical to connect a multi-stage turbine direct to the power and compress by this system hydraulically, rather than to belt or gear on a reciprocating compressor. In comparing the efficiency of the two systems, it should be borne in mind that the hydraulic system requires no auxiliary pump to circulate cooling water, exerts a uniform resistance on the driving motor, compresses the air at a lower temperature, and the air delivered is drier and free from lubricating oil.

COMPRESSED AIR IN LAUNDRY WORK

The application of air compressors to laundry work has invariably been successful, and the demand for them for such service is increasing. Generally speaking, it is always a two-pressure service, a very low pressure for use with gas burners, sprayers, and heated rolls, and a higher pressure for presses used in the dampening process.

Two laundries may be taken as fairly representative of modern practice in this line, and a description of their air plants are as follows: One of these plants makes a specialty of hand work, having about 50 hand-ironing boards, and four rolls of ironing machines. Each ironing board is provided with a flat-iron heater and connected to both gas and low-pressure air supply. By properly regulating the admission of gas and air, a very hot blue flame is obtained throughout the interior of the heater and, of course, this flame can be adjusted to give any degree of heat desired. Rolls of ironing machines or mangles are similarly heated by jets of gas and air.

All of the above devices use air at three or four pounds pressure. There is one press, the cylinder of which is 8 inches in diameter and 24 inch stroke. It is vertical and supported by columns at a height sufficient to allow trucks with boxes about two feet square and three feet high to be run under it. After the clothes are dampened, they are placed in these box trucks until the box is nearly filled. A cover is then placed over the top of the clothes and the truck is run under the press. The air pressure used is 50 pounds.

They also have hose connections on each floor, connected with the high-pressure supply, for cleaning out their motors and machines. (All machines are run by individual electric drive.) They also use the high-pressure air for blowing whistles on each floor at the time of starting and stopping the plant.

Their compressor plant consists of a 9½x11x10 inch air compressor with plain air cylinder, controlled by a governor set at 55 pounds, and mounted on the end wall of the building on the second floor. Boiler pressure is 100 pounds, and the exhaust is used for heating the building and feed water. The air inlet to the compressor is piped through the top of a window nearby. The air is discharged into two 26½x54 inch reservoirs coupled in series. Both high and low pressure air lines are taken from the second reservoir, a reducing valve controlling the low-pressure line.

The pipe lines run along the walls near the floor, and under the floor to each machine. The ironing boards are placed mostly along the walls at right angles to them and connected to both air and gas lines directly by small rubber hose. The size of air pipe lines varies from 1 to 3/8 inch, the size being reduced at intervals as the distance from the compressor plant increases.

The free air consumed by these various devices cannot be stated so as to form a general rule, since different operators regulate their gas flames differently. But it is noted that when about 20 or 25 ironing boards and 4 rolls were in continuous operation, the pump indicated a consumption of from 16 to 20 cu. ft. of free air per minute, approximately.

The management of this laundry is highly pleased with the compressor plant, and stated that their business has increased 20 per cent. during the time since the compressor was installed, while their gas bills had been reduced 20 per cent. by the introduction of compressed air, or a saving of 33 1/3 per cent. in gas consumption had been effected by this means.

The other establishment mentioned does general laundry work, having about 20 ironing boards and 12 rolls. (They also have 3 or 4 mangles, but heated by steam.) Their low-pressure line is carried at 33 pounds.

They have two presses, one 5 inch diameter by 18 inch stroke, and one 8 inch diameter by 24 inch stroke. These presses are placed on the floor and press upward; the patent box trucks are not used, the clothes being placed in a frame that is a permanent part of the top of the press. When the frame is nearly filled, pressure is turned into the cylinder and allowed to remain there for about half an hour till the clothes are ready to be removed. Thus the operation of these presses occurs about once every half hour during the entire day.

They are also using high-pressure air in their boilers as a *smoke consumer*. This air is injected by jets into the smoke over the top of the fire, the idea being that the mixture of air and fine particles of coal form a combustible mixture which burns far into the tubes, causes less deposit in the latter, increases the steaming power of the boiler, and allows the temperature of the fire box to be lower, for the same boiler performance and fuel consumption, besides almost entirely eliminating the smoke. Their high-pressure is supposed to be 50 pounds, but when operating the smoke consumer it often drops to 35 pounds.

Their air plant consists of one 9½x11x10 inch air compressor with plain air cylinder, controlled by a governor set at 55 lbs., and mounted on uprights between floor and ceiling of their power plant in the basement. The boiler pressure is 90 lbs. The air suction is piped to an open basement under an extension of their plant, the length of suction pipe being about 12 or 15 feet. They have 100 feet of discharge pipe between the pump and storage reservoirs. The latter are two 26½x54 coupled in series with a reducing valve between them, so that one reservoir is high pressure and the other low pressure. The two air lines are taken rrom the respective high and low pressure reservoirs.

With the entire plant operating, except the presses (including smoke consumer), the compressor made about 28 cubic feet of free air per minute. Without the smoke consumer, it made about half that amount.

Another use for compressed air, not used in either of the above mentioned laundries, but installed in some others, is the mist and spray dampeners. The pressure required is only a few ounces. The use of this dampener is not continuous, each employe starting and stopping it for his own use, and as the dampening process is very quickly performed, the average air consumption is very small.

Compressed air is so useful for a multitude of other purposes, that it bids fair before long to become a recognized necessity for all well equipped laundries.—*National Laundry Journal.*

MELTING SNOW IN RAILROAD YARDS

One of the most serious winter tasks in railroad yards in winter is the keeping of the switches free from ice and in operative condition. Snow and sleet storms; water from leaking locomotive tanks, overflow from injector pipes and engines, drips from car heating, and water from train lavatories and kitchens, emptied into the switch and interlocking mechanisms are constantly throwing them out of service. Various schemes have been proposed and different arrangements have been tried, nearly all necessitating extensive and costly installation under and around the switch apparatus and after all being liable to give out when their services were most needed.

During the past year a new system of snow melting has been used at several of the large terminals, and we find an intelligent sketch of it in a paper by Mr. James S Lang, read before the Railway Signal Association of Chicago. The praticability of the system has been demonstrated during the past three winters at one of the busiest terminals in the country, with the result that delays due to snow and sleet storms have been almost entirely eliminated.

An extremely low cost, both of installation and operation, is possible on account of the small amount of apparatus required in comparison to the number of switches protected. Instead of requiring piping or permanent apparatus for each switch, several switches are handled with no more apparatus than is necessary for one, and nothing that might in any way interfere with either operation or the repair of switch or track is used. Even complicated and busy yards may be taken care of by the regular track and interlocking forces without any extra help whatever. The saving in operation by this method as compared with the usual method of hand cleaning will pay the entire cost of installation in a single large storm.

Hand Cleaning Yard Switches.		
150 extra men, 24 hours each, 360 hours, @ 20c......	$720.00	
33 regular men (including foremen), 30 hours each...	181.70	
Meals: 150 men, 3 meals each, 450 meals; 33 regular men, 3 meals each, 99 meals; or a total of 549 meals, @ 20c..................................	109.80	
		$1,011.50
Using Snow Melting System.		
No meals (men enabled to leave for meals).		
No extra men.		
Regular men, 20 hours each (duration of storm 24 hours, absent 4 hours for meals)...................	$121.80	
Hydrocarbon, 1,900 gallons @ 4c..................	76.00	
Incidental charges, and rentals, which might regularly be charged to storm in question..................	66.60	
		$264.40
Saving effected in one storm.........................		$747.10

COMPARISON OF COSTS OF CLEANING SWITCHES.

The melting of the snow or ice is effected by applying to it a flaming fluid which continues to burn while in the snow, melting and finally evaporating the greater portion of it. The character of the fluid is such that the flame is easily maintained regardless of high winds or drifting snow.

The fluid is applied by the regular track force by means of a safety distributing can, and the height and extent of the flame can be regulated with ease. No injury to track results, as the temperature of the rails is not raised to the usual summer heat, while the fluid, being a hydrocarbon, acts as a preservative of the ties. At night the light given off by the flame by rendering the forms of men visible, lessens the danger of personal injury.

One of the first steps in installing this system is necessarily the installation of sufficient storage capacity for the liquid. This would vary in proportion to the number of switches which it was desired to keep operative, the average severity of the storms and the facilities for obtaining the fluid. The fluid is obtainable in the open market at from three to five cents a gallon, and may be obtained free of cost by railroads operating their own Pintsch gas plant.

At one plant, where this system has been in use, the tank, having a capacity of several thousand gallons, was connected with the compressed air used by the interlocking system, and when about 10 lbs. air pressure was admitted to the tank, the liquid was forced, through buried piping, to the several drawing outlets, located in various parts of the yard.

The storage arrangements may therefore vary from only a single 200 gallon iron drum, elevated upon blocking, where only a few switches are to be looked after, to a tank of several thousand gallon capacity feeding various lines of underground piping, in yards where the number of switches is large and the territory extensive, or where it is inconvenient or dangerous to cross tracks; or where there is no convenient nearby location for a tank.

The supply stations for the distribution of the fluid are provided with safety self-closing faucets, and drawing gages which enable the operator to readily tell, when the cans are being filled, how much fluid they contain, and how much is being used.

The table gives data derived from experience in a storm occurring during the past winter at one of the busiest yards. In comparison with the results obtained by the hydrocarbon system is given a careful estimate of corresponding cost of hand cleaning, based upon the experience of previous years and corresponding snowfall.

This severe storm was taken care of without a single delay chargeable to snow, and switch failures were less than one per cent. of the usual number.

LIQUID AIR AND THE PRODUCTION OF OXYGEN

The voluminous judgment of Lord Justice Fletcher Moulton in the case of the British Liquid Air Company *vs.* the British Oxygen Company, Limited, comprised among other things, a dissertation on the history and practice of the production of oxygen from the air by mechanical means, which was summarized in a recent issue of the *Engineers,* London, and which summary is here presented in a more condensed form.

The phrases "partial co-operation," "fractional evaporation" and "fractional distillation," accurring frequently in the evidence and argument have first to be defined. Evaporation is, of course, the change of liquid into vapor; that is from the liquid into the gaseous form. Distillation, etymologically, is the separation or recalling of the liquid from the form of vapour to its original state by means of condensation. By usage, however, distillation has come to mean the whole operation of evaporation and subsequent condensation. When the liquid operated on is a mixture of components differing in volatility, the more volatile component will be the more esaily evaporated, and the resulting vapor will be richer in it than was the original mixture. If, then, this vapor be condensed, the resulting liquid will still be a mixture of the two original components, but will be much richer in the more volatile component than the initial mixture. This operation is known as "fractional distillation," and it is affected by "fractional evaporation" followed by condensation. It is evident, however, that the original liquid gets weaker and weaker in the more volatile component as the operation is continued, and if it is desired to get as strong a resulting mixture as possible the operation must not be pushed too far, or, in other words, the original liquid must only be partially evaporated. "Partial evaporation," therefore, is practically synonymous with "fractional evaporation" when it is used in connection with the process of distillation.

In the progress of the case upon which this judgment was rendered, considerable confusion had arisen through the use of the word "pure" as applied to gases separated by the various types of apparatus under consideration. This was not to be wondered at. The apparatuses in question were producing on a commercial scale a product which was sufficiently free from admixture to be practically and commercially equivalent to the chemically pure article. Of course, for scientific reasons, absolute purity could not be looked for with any such processes as those involved, and from the evidence it appeared that 98 per cent. was the purity which could be obtained by careful working, and this should be borne in mind whenever the word "pure" is applied to such products.

The subject matter of the inventions with which the case deals are of the greatest interest. They relate to the first commercial application of the scientific advance that has been made during the last quarter of a century in obtaining extreme cold. The names which occurred in the evidence were of those who were the pioneers in this advance—Raoul Pictet, Cailletet, Dewar, and Linde. The first two shared the honour of being the first to liquefy air; Dewar was the first to obtain liquid air in substantial quantities, and was the first to liquefy hydrogen; Linde, by his inventions of 1895 and 1902, had made what seemed to be the two most important contributions to the practical utilization of these low temperatures. It had been long known that when compressed air was used to do external work there was a great fall in temperature. It had also been shown by Sir William Thomson and Mr. Joule that if compressed air were allowed to expand without doing external work there was some fall of temperature, due to the fact that internal work must be done in such expansion. Linde was the first to recognise that this cooling effect be increased very rapidly as the temperature fell, and he used it to make a most practical and effective air-liquefying apparatus. Air was compressed to a very considerable pressure. This raised its temperature. It was then cooled by letting it flow through coils immersed in water. It was then passed through the inner pipe of a coil of double metal piping, that is, a coil constructed of a pipe which itself contained an inner metal pipe having the same central line. This double pipe at its further end communicated with a closed vessel, the end of the outer pipe opening freely into it, but the end of the inner pipe being provided with a stop-cock to regulate the rate of escape of the compressed air into the closed vessel. The other end of the outer pipe communicated freely with the atmosphere. On its admission into the closed vessel the compressed air expanded and fell in temperature. As it passed away to the atmosphere through the outer tube it cooled the air in the inner tube. This cooling of the compressed air caused the cooling effect of its expansion to become greater. The refrigerating effect continued to increase until at length the cold became so intense that a portion of the incoming air liquefied and collected in the vessel. He thus obtained a continuous process for producing intense cold, and thereby liquefying gases by "countercurrent-interchangers"—as the arrangement is called—which process is of great practical value.

Linde, however, did not only aim at the production of liquid air, for which there is no great commercial demand. What he did hope to do was to obtain substantially pure oxygen from the liquid so produced. In this he relied on the fact that nitrogen is more volatile than oxygen, and hoped that it would volatilise more quickly than the oxygen, till practically all of it was gone and only oxygen remained. When Linde took out his 1895 patent he overrated the efficiency of this method. It is quite practicable to get a richness of, say, 60 per cent. of oxygen in this way, but when the process is carried further so much oxygen itself comes off that by the time the required purity is attained so little "pure" oxygen remains as to render the process useless for commercial purposes. His 1902 patent, however, which has since been acquired by the defendants, enabled him to manufacture successfully and commercially substantially pure oxygen.

Fig. 1 is from the Linde patent of 1902. Compressed air cooled by counter-current-interchangers is conducted to the lower chamber of the vessels. This lower chamber is separated from the upper part of the vessel by a tube plate forming the support for numerous metal tubes, which are closed at their upper ends—so that there is a flow of air into but not through them—and which project into the upper portion of the vessel *s*. This upper portion is full of a liquid which contains about 98 per cent. oxygen and 2 per cent. nitrogen. This liquid is practically at atmospheric pressure because the vessel is open at the top and the space in which it is enclosed is in free communication with the atmosphere through the outer coil of the counter-current interchanger, the coils of which are arranged to form close walls round the space in which the vessel *s* is situated, so that it is insulated from the air and surrounding objects, and can be kept at a sufficiently low temperature to permit the mixture in it to remain liquid.

The action of the apparatus is as follows: —The compressed and cooled air enters, as has been said, into bottom part of the vessel *s*, and in doing so fills the tubes above referred to. These being surrounded by liquid oxygen at atmospheric pressure, a temperature is produced which is sufficiently low to liquefy the air in them, and the resulting liquid falls into the receptacle below the tubes. As time goes on such a quantity of liquid collects that it is forced by the pressure of the incoming air up the pipe on the right-hand side, which is provided with a stop-cock, and which communicates with the top of *r*. This is what is known as a rectifying column, and it contains a quantity of glass balls. The liquefied air, which, it will be remembered, has already had its temperature reducted to that of boiling oxygen in the bottom of the vessel *s*, as it is delivered at the top of the rectifying column *r*, suddenly has its pressure reduced to that of the atmosphere. It is accordingly very much cooled, and in this condition it falls down among the glass balls, up through which there is continually rising the vapor of the practically pure oxygen contained in the upper part of the vessel *s*. The consequence is that the comparatively warm oxygen vapors, which start at a temperature of about 91 deg. absolute, meet the cold liquid air, which starts at a temperature of about 78 deg. absolute, and as the two meet among the glass balls "an infinitude of small partial evaporations take place, in all of which the more volatile element nitrogen has the preference and rises as a gas, and the less volatile oxygen condenses and falls as a liquid." The consequence is that most of the nitrogen escapes, carrying with it a small proportion of oxygen, and by the time the oxygen reaches the vessel *s* it has got rid of all but about 2 per cent. of its nitrogen. As a result the strength of the liquid oxygen in *s*, though the amount of the liquid is continually increasing, remains at about 98 per cent. when the apparatus is in full work. The vessel *s* overflows into the vessel *t*, and the gas evaporated from that vessel is commercial oxygen.

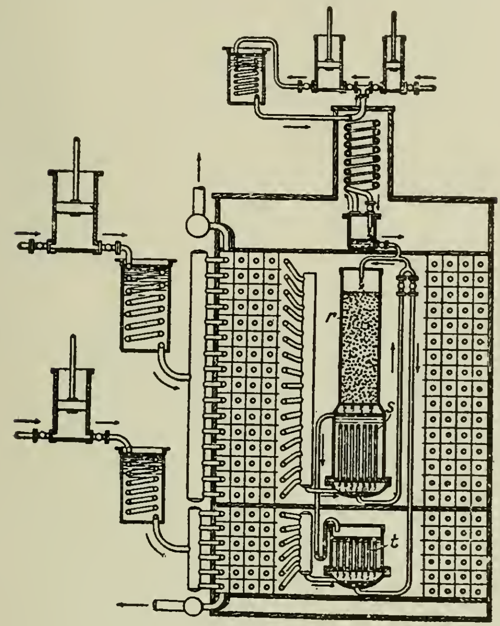


FIG. I.

When dealing with the novelty of employing a rectifying column in the process of separating oxygen from a mixture of oxygen and nitrogen, Lord Justice Moulton thought it was not a mere transplanting an old device to another soil more or less analogous, but that there had to be inventive preparation of that soil before successful transplantation could take place at all. His reasons for this view were given at some length, but we need only say that in his opinion Linde had made the entering stream of compressed and cooled air play the double *rôle* of the boiler fire and cold wash in the Coffey still. He had done this by availing himself of the intense volatility of the materials with which he was dealing, which enabled him to make them change their state by variations of both pressure and temperature. So far from his success being due to the new circumstances being analogous to those of the Coffey still, he—Lord Justice Moulton—considered that Linde's invention was based on their being different. He had not succeeded not only in spite of these differences, but because of them.. To say that no invention was required to achieve this was to his—the judge's—mind absurd.

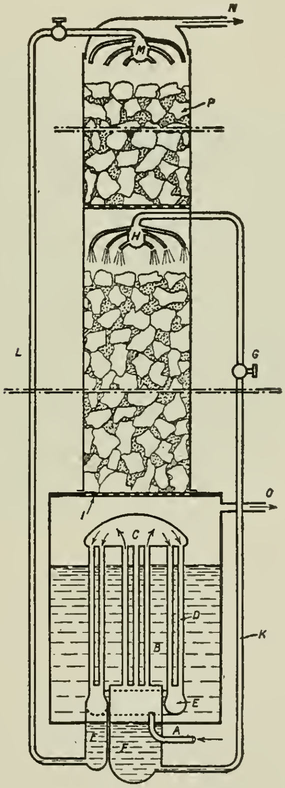


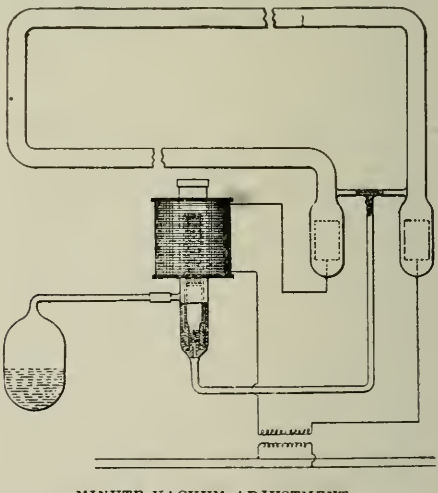
FIG. II.

The defendant's machine described above was then compared with that of the plaintiff, sketched in Fig. 2. The compressed air here enters at *a*, after having been cooled by the emergent gases in counter-current interchangers, as in Linde's invention. These interchangers are not shown in the engraving, but are admitted to be essential to the working of the machine. The plaintiffs thus make use of the first three essentials described in Linde's patent. The cooled and compressed air is led into the lower chamber of a vessel K, corresponding to the vessel *s* in Linde's apparatus both in position and function. This lower chamber is separated from the upper part of the vessel by a tube plate forming the support for numerous metal tubes which project into the upper chamber of the vessel E. There is thus a flow into these tubes but not through them. The upper portion of K is an open vessel which contains practically pure oxygen at atmospheric pressure, and his oxygen is evaporated by the latent heat of the compressed air which passes through the walls of the tubes immersed in the liquid. All this is precisely the same as in Linde's apparatus. The only peculiarity to be found in the plaintiff's mode of performing this operation as contrasted with that shown in Linde's specification is that the tubes in the plaintiff's machine are diagrammatically in the form of an inverted U and are not straight. This change in the shape of the tubes does not affect the condensation which goes on therein, but it affects the collection of the condensed liquid. In the defendants' apparatus the whole of the condensed liquid runs back into the receptacle beneath the entrance to the tubes, and collects there. As shown in Fig. 2—the plaintiff's apparatus—the condensed liquid that is formed in the first half of each tube, that is, in the ascending leg of the inverted U, falls back into the receptacle F beneath the entrance to the tubes, but that which is formed in the descending leg of the U falls to the further end of the tube into a corresponding receptacle placed there to receive it, and which constitutes the termination of the tube, so as to make it a closed tube so far as the passage of the entering air is concerned. Both the liquids in E and F contain mixtures of oxygen and nitrogen, but of varying strengths, that in F being the stronger as regards percentage of oxygen.

Having thus procured their liquefied mixtures, the plaintiffs proceed to separate the oxygen from them. For this purpose they use a rectifier just as Linde does. The two mixtures of nitrogen and oxygen are forced by the air pressure to different elevations in this rectifier, the weaker, as might be expected, being taken to the higher level. This is the only difference, his Lordship explained, and he stigmatised it as "a mere commonplace in the use of rectifying apparatus." In his opinion, therefore, the plaintiffs' machine is a clear infringement of the defendants' patent, for it operates by possessing the three essentials of Linde's invention, set out as such in his specification:—(1) It cools the air to be condensed by causing it to flow in the contrary direction to that of the evaporation products; (2) it then causes the same to transmit its heat to the evaporating liquid; and (3) it then causes the vapors produced in the distilling apparatus to flow upwards through the liquid air flowing downwards in a stratified manner. "Every word of this description," he said, "applies to the plaintiff's machine just as aptly and just as completely as it does to that shown and claimed in the defendants' patent.

MINUTE VACUUM ADJUSTMENT

In vacuum apparatus, after continued pass of the electrical energy and the heating of the glass walls the vacuum is observed to increase, and, as a certain condition of partial vacuum is necessary, if the exhaustion ranges too high the required impressed voltage effects a passage of electricity through the extremely rarefied gases and becomes so high as to be inefficient. By the invention of Daniel McFarlane Moore any desired gas is auto-



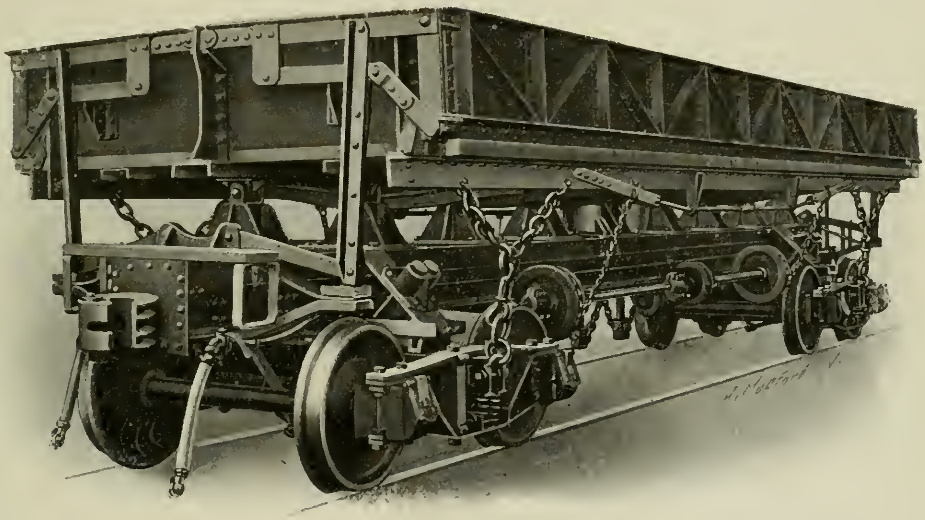
MINUTE VACUUM ADJUSTMENT.

matically introduced into the tube. The arrangement of the inlet valve is shown in the cut which we reproduce from *The Western Electrician.* The apparatus consists of a storage tank or receiver for a readitly vaporizable liquid connected to the vacuum tube through the valve which is electromagnectically controlled by the winding in series with the main lamp current. The branch tube leading into the lamp is shown filled with sand to prevent short-circuiting of the high-tension discharge.

The valve itself contains a pool of mercury which normally seals the imgress opening through the displacement due to the presence of a plunger. As the current in the tube increases the magnet winding lifts its armature, withdrawing the displacer and allowing the mercury to drop away from the inlet opening, thus admitting the gas which is given off by the liquid in the container. A minute quantity only flows before the pressure rises so as to cause the magnet to close the valve and stop the flow. A reduction of tension in the flask and communicating spaces up to the regulating valve below that which is necessary to practically maintain the contents in the liquid or solid condition will permit the evolution of more gas or vapor, which will, therefore, be ready at a higher pressure in the chamber than in the tubes, so that a feed of gas will take place whenever the communication is opened by the gas-regulating valve.

AN AIR DUMP CAR

The half tone shows a new 20 yard air dump car built by the William J. Oliver Mfg. Co., Knoxville, Tenn. This car is strongly built throughout to stand the severe service of handling earth and rock. The draft sills are built up of two steel channel beams, with separators, cover plates, etc. The bottom is of 3 inch oak reinforced by a 10 inch steel center channel the full length of the body, also by two intermediate sills made of 8 inch channel beams and by two outer edge angle braces. The car is trussed by two 1½ inch rods with turn-buckles. The center sill is pivoted to rim hinges on the draft sills. The steel plate doors are reinforced longitudinally at the top and bottom and also vertically by angles.



NEW OLIVER DUMP CAR.

The car has a long truck base distributing the weight over a large area of false work, and in dumping all material goes clear of the trucks and oil boxes. There is a toggle door raising lever arrangement and as the car is dumped the lower edge of the door is thrown upward and away from the contents of the car, thereby minimizing the liability of material striking against and wedging or springing the door. The same toggle device also locks the doors securely when the car body is in the horizontal or load carrying position.

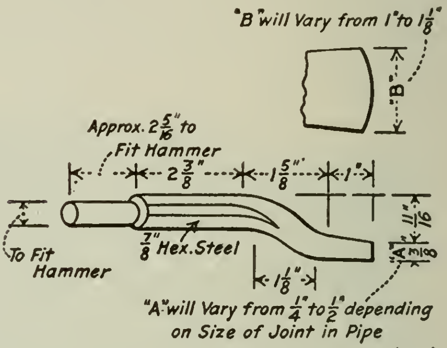
Under the car are two air pipe lines; the air brake pipe and the air dump pipe. At each end of the car is a three way cock from which there are two branch pipes connected to the two dump cylinders, so that the car can be dumped from either end. In the operation of dumping air is turned by the three way cock into the air cylinder operating the longitudinal shaft on the designated side. This causes a downward movement of the air dump piston to the rod of which is attached a sheave which pressing upon a chain causes the longitudinal shaft to turn and the turning of this shaft causes a downward pull of the dump chains which are attached to one of the sheaves on the end of the shaft and at the other end to the body of the car thereby bringing the body of the car to the dumping position. To bring the car body to the horizontal position again air is turned into the cylinder on the other side of the car. When the car body is being tipped the pistons travel in opposite directions.

The car is equipped with the Oliver patent steel non-clogging coupler. It has the standard M. C. B. contour, with solid top and open bottom, so that if earth should get inside of the coupler casting it would not lodge there and interfere with the operation.

A PNEUMATIC TOOL FOR CAULKING PIPE

Mr. A. E. Walden, Superintendent and Chief Engineer of the Baltimore County Water and Electric Company, contributes to *Engineering News*, from which we reproduce it, the following account of his experiences in laying a long line of water pipe, the narrative having to do principally with the caulking of the joints by a specially adapted pneumatic tool.

In 1906 the Baltimore County Water and Electric Co. started to lay about 25 miles of 12, 10 and 8-in. pipe cross country to take care of a section that was supplied by deep wells which had given every evidence of failing entirely and prevented taking on additional consumers, and giving satisfactory service to consumers already connected. It was soon found that expert and rapid caulkers could not be secured and a portable compressed air plant for caulking, cutting and drilling was purchased and mounted on a truck, which proved a success in every respect, though some trouble was experienced with the gas engine. It was found possible to calk a 12-in. pipe satisfactory for 250 lbs. working pressure in 2½ minutes, the average of all joints being between three and five minutes. The joints were more satisfactory and were tight in every respect. The average actual time for hand calking on this size pipe was 30 minutes, but the all-day average was 45 minutes. At one time two men, with the air hammers, calked between 8 a. m. and 5 p. m. 76 lengths of 12-in. pipe out of a total of 87 pieces laid and leaded. This work was done in cold weather, which made it difficult to get the best results. This line is operating under pressure of from 100 to 250 lbs. per sq. in., depending on the elevation, and so far there has not been a joint leak where the air tool was used. The time required to cut 12-in. pipe was 2½ minutes. The portable plant was made up as follows:


"B" will Vary from 1" to 1⅛"
"B"
Approx. 2 5/16" to Fit Hammer
2⅜"
1⅝"
1"
To Fit Hammer
⅞" Hex. Steel
11/16"
"A"
3/8
1⅛"
"A" will Vary from ¼" to ½" depending on Size of Joint in Pipe

A 6-HP. gasoline engine was belted to a small duplex air compressor capable of maintaining 70 to 80 lbs. air pressure when delivering 32 to 35 cu. ft. of air per minute, with storage and cooling tank and a small centrifugal circulating pump for circulating the water through the jacket. The engine was of the single cylinder vertical type, but it was found that a two-cylinder engine would have been better, and it is possible that one of the small, air-cooled, multi-cylinder, marine engines would have given the best results. The equipment was mounted on trucks, and provided with two lengths, of 150 ft. each, of ½-in. air hose connected to a storage tank at two different points so that it would only be necessary to move the machine once in every 300 ft. An air-hammer drill was provided operated from the same equipment capable of drilling up to 4-ft. holes. In the niggerhead formation it was possible to drill at the rate of 2 ins. per minute.

Two sizes of hammers for calking were purchased, one 3-in. and one 2-in. The 3-in.

hammer was a success, as the shorter-stroke hammer jarred the operators' wrists so that they could not operate steadily. The proper shape calking tools could not be secured from the hammer manufacturers so that it became necessary to have them made up locally. These tools are shown in the accompanying figures. The cost of the entire equipment ready to operate was $665, including engine and truck, all tools, drills, hammers, etc. The usual antipathy of men toward labor saving devices was encountered but the results obtained demonstrated the possibilities of the equipment to do even better work than it did here. The same truck is now to be equipped with a small centrifugal pump for pumping out trenches, etc., and will thus make a very compact outfit. It was found that the construction of the hammer could be improved by providing a spring clip that would snap over a collar on the tool to allow of the tool turning easily in the socket, but so constructed that it would prevent jumping out when starting the joint. In calking where a joint "is poured" if the lead slug is driven in and swedged off (not cut off) with the tool no leaks will occur at a joint calked with the air hammer, and it is possible to drive the joint hard enough to crack the bell.

LOCAL WELDING IN RAILWAY SHOP WORK

The following occurs in a valuable series of articles by Charles R. King, upon European Locomotive Work in recent issues of *The Engineering Magazine.*

The new processes for welding have been of the greatest utility for the work of railway shops, for they permit of the metal being fused *in situ* without having to dismount the parts to be repaired. Even a broken bridge in the orifices of a valve-chest liner can be sometimes "touched" with the flame and the liner then rebored in place. In the work of new constructions these welding processes are largely employed. At the La Chapelle (Paris) shops of the Nord Railway the oxyhydric process is in use for welding all thin plates not subject to special working strains. Boiler flues are pieced together and frame plates are welded or soldered, after being fractured in service. For joining the clothing plates of boiler or cylinders—which require to be hermetic when no non-conductor is used for lagging the boiler—it is especially serviceable. A length of 1 metre of 1-millimetre thick plate is welded in 10 minutes, consuming 20 litres of oxygen and 100 litres of hydrogen and costing, together, 14 centimes=barely 3 cents; one metre of 2-millimetre plate is soldered in 15 minutes, consuming 60 litres oxygen and 280 litres hydrogen. The proportion of hydrogen is much above the theoretical value in order to avoid oxidation. Frame plates or parts attached, are repaired with a consumption of gas differing widely in proportion to the importance and difficulty of the operation. For instance, suppose a crack 5 inches long in the angle of horn-plates or axle-box guides ("pedestals"), the depth being 1¼ inches. The metal to be run into the cavities, that machined inside and outside to half-depth, calls for an expenditure of 1,500 litres of oxygen and 8,800 litres of hydrogen, costing 11.39 francs, say $2.28. The removal of the plant, its installation, the welding, and the return of the plant, takes the smith and his help 2 hours, costing 2.45 francs, so that the whole repair comes to 13.84 francs.

The process is also employed in the construction and repair of steel and iron pipes, of ash-pans, locomotive footplates, and for all kinds of repairs where the flaws are superficial and compromise neither strength nor safety.

The outsider, in watching the process. sees the operator wearing dark spectacles holding the burner against a 1¼-inch frame plate. The flame first blisters superficially; the iron then gradually becomes a blotchy red, losing color directly the flame is moved away, then reddening through the whole depth of the metal, and finally becomes white and attains the point of fusion, when the soft iron rod to fill the cavity is introduced and fuses with the neighboring metal of the plate being welded. With boiler flues the two coned and hollowed ends of the tubes are lightly butted together while resting on a X-trestle, and the operator touches the joint with the flame forming a series of little fused points, turning the tube slightly with each touch of the flame. Each operator welds 120 flues daily, or an average of 5 minutes per tube, the cost in gas for each 10 tubes being 100 litres oxygen and 650 litres hydrogen, costing, together, 81 centimes or 16 cents. The saving as compared with the old system of brazing amounts to 40 centimes (8 sous or 8 cents) per tube. or enough to pay for the gas required to weld 5 tubes.

An assistant removes the welded tubes and passes one extremity of the flue through a hole in a block, leaning on the other extremity, turning the tube slightly at each pressure. The tube, according to the foreman, never breaks at the joint but gives way at any other part if the tube is tested to destruction.

Summing up the price of shop work in connection with this form of welding, each tube costs 32 centimes, or 6½ cents, for labor; that is, cleaning and cutting down old tubes, sawing off and chamfering the new ends for the firebox extremities, welding, straightening; tests in the block and at the hydraulic press, and trials at the store reception. The gas costs 0.81 centimes per tube, consequently each tube thus welded costs, altogether, 40.1 centimes or 8 sous or cents.

The saving by this process for welding ribbed tubes of the Serve pattern is even greater—that is 13 sous or cents per tube. The ends of the tubes are hollowed and coned as usual, the lip on the hollowed end furnishing the metal for the fusion of the joint. Each tube-weld necessitates 60 litres oxygen and 243 litres hydrogen, together worth 37 centimes or 7½ cents. Each installation turns out 60 welded tubes per day or an average of 10 minutes for each ribbed tube, for which 4 sous or cents per tube is allowed. The entire cost per tube amounts to 25 sous or cents—one shilling—in including cleaning, selecting, and cutting down of tubes, removal of ribs at the extremities, sawing off the new end, chamfering the joints and, at the same time, removing the ribs near to the weld, welding, straightening and testing.

The two kinds of gases are delivered in steel cylinders of 47 litres capacity and at a pressure of 150 kilogrammes per square centimetre. Reduced to atmospheric pressure, each cylinder therefore contains about 7 cubic metres of gas for which 16 sous or cents is paid to the "Société L'Oxhydrique Française" per cubic metre of hydrogen and 58 sous per cubic metre of oxygen. For thin metal up to 3 millimetres thickness this process is as quite as economical as the oxyactelenic process of welding, but beyond that thickness the latter is the more economical. By reason of its less intense whiteness the glare of the oxyhydric flame is said to fatigue less the eyes of the operatives.

A NATURAL AGGREGATION OF RARE MINERALS

F. L. Hess, of the United States Geological Survey, in a report just published forming a part of an advance chapter from the Geological Survey's Bulletin No. 340, calls attention to perhaps the most remarkable natural mound in the United States. It is in the middle of the "Llano region," an "island" of pre-Cambrian rocks almost in the geographical center of Texas, known as Baringer Hill and celebrated for its content of what geologists term "rare earth metal minerals." In a short description of this hill, which is formed by a "dike" and is only about 40 feet high and about 100 by 200 feet in lateral dimensions, is given a list of about two dozen minerals found in this small area, among them a number of radioactive materials and others of great and increasing practical importance. Among the rare-earth minerals at Baringer Hill are fergusonite, gadolinite, polycrase, yttrialite, and cyrtolite.

The economic interest in these minerals is due to the incandescence of their oxides on being heated. This property makes them available for use as glowers in gas and electric lamps. Tnoria, beryllia, yttria, and zirconia are the most useful minerals employed for this purpose. Until the discovery of the deposits at Baringer Hill it was practically impossible to get sufficient yttria bearing minerals to manufacture mantles for electric glow lamps; but fergusonite and gadolinite, with lesser amounts of cyrtolite and other minerals containing yttria, occur here in quantities large enough to meet the demand. The Nernst Lamp company owns this valuable deposit, but its needs require only the occasional working of the mine. After enough yttria minerals are obtained to supply its wants for several months the mine is closed. Only a few hundred pounds a year are extracted.

The geologic island in which Baringer Hill is located is interspersed with other mounds and dikes of similar appearance, which have been considerably prospected, but without much success. Mr. Hess states that as these rare-earth minerals constitute only a small fraction of 1 per cent. of the total mass, commercially large amounts may exist in a dike and not be exposed at the outcrop; but suggests that cracks that generally surround the nuclei of the minerals may be utilized in prospecting.

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COMPRESSED AIR CONSISTENCY

A maker should certainly appreciate and employ to his own advantage the goods or appliances which he is urging others to buy; yet there are those who do not. This general topic having been opened recently by our esteemed contemporary *Machinery* to whom a correspondent writes as follows:

"The writer can call to mind several instances where manufactuers show their inconsistency in this respect. This can be best illustrated by a specific case, referring to a concern capitalized at $300,000, and manufacturing steam engines, air compressors, water in-takes operated by compressed air, air-lift systems, centrifugal pumps of all sizes, and several other kinds of machines for pumping purposes. This firm has a machine shop, foundry, wood shop, pattern shop, blacksmith shop, and ware-house—all modern buildings. These shops all receive their power from a central power plant equipped with a Corliss engine and a direct current generator. The machine shop is equipped with an electric traveling crane, while the foundry and blacksmith shop have jib cranes operated by hand. The concern has spent thousands of dollars for jigs in order to lower the cost of production. The shops are lighted by electricity, and the clock system of time keeping has been installed. Besides this, there is an excellently arranged stock department.

"Contrasted with this is the equipment of the foundry. Since this firm manufactures air compressors, one would naturally expect to see some pneumatic tools in operation, especially in the foundry; but no, all the riddling and chipping is done by hand. Pieces that are too large to put in the rattler are brushed and cleaned up by hand. And, to cap the climax, instead of using one of the firm's own air-lift pumps for the water system, there is an old power pump jack that keeps the water well oiled, and breaks down regularly once every two weeks.

"Now this firm's trade in air compressors has fallen off considerably in the last two years, due, it is claimed, to the competition in that line. It is the writer's opinion that if this firm would practice what it preaches, it would be able to get in on the ground floor with the other fellow. The use of air hammers, air chisels, air brushes, sand blasts, emery wheels operated by air, air drills, riddles operated by air, and air lifts, would not only cheapen the labor cost, but the practical application of compressed air to the work of the machine shop, foundry, blacksmith shop, etc., would be an object lesson to the intending purchaser that would tend to hasten his decision."

There will be opinions as to the propriety of, and as to the good taste displayed in, such revelations as this. We have ours, and we have taken pains not to know the identity of the establishment above referred to. We do known, however, that there are establishments, capitalized at more than $300,000, to which these remarks do not apply. We have in mind one establishment, which builds air compressors and other things, where a supply of compressed air at two different pressures is carried throughout the works by many miles of piping, and where all the devices spoken of above as conspicuous by their absence, and many others which the alert looking out for economy and conveniences have suggested, are in constant employment. This everyday familiarity of all hands with compressed air practice constantly leads to new applications and to the originating of new devices which ultimately are offered to customers. Not only are the possibilities of compressed air here appreciated and the range of its adaptability availed of, but its limitations also are understood, and nowhere is compressed air used perfunctorily. The entire establishment is electric driven, with individual motors for the larger or isolated machines and light electric driven line shafts for the smaller tools. No line shafts, belts, cables or steam pipes run out of the power house to the various buildings. The air pipes and the electric wires run side by side, their only accompaniments being the going and returning water pipes for the heating service. Such an establishment is in position to advocate intelligently and consistently compressed air practice and its own compressed air appliances.

COMPRESSED AIR PROGRESS

In the course of his classical researches into the steam engine and other prime movers, Professor Rankine showed the great theoretical advantages of the air engine, as compared with motors using a fluid such as steam, which changed its state from the gaseous to the liquid form during the development of active energy from heat. The air engine, in the forms in which he considered it, however, never became a commercial success, although some of the principles upon which his analysis of it were based enter into the operation of the modern internal-combustion engine. Nevertheless the advantages of the elasticity of air, in connection with the transmission and application of power, have acquired great mechanical and commercial importance, and the air compressor, in its latest and highest types, together with the numerous useful machines for the application of compressed air, has become an accepted manufactured product, comparable in magnitude and importance with the steam engine.

It is especially in connection with the transmission of power to certain classes of operative tools that the air compressor has found successful application. The rock drill, it is true, is often operated by steam taken directly from the boiler, but this is in cases in which the distance between the generator and the operative machine is comparatively short and the temporary nature of the work renders the losses by leakage and condensation relatively unimportant. In extensive mining work, in important tunneling operations, in the great majority of cases compressed air is employed, its use carrying with it absolute assurance against the serious loss from condensation accompanying the use of steam, together with freedom from excessive heat, annoying drip of water, and minor inconveniences well known in practice.

In the machine shop the air compressor has become an accepted element in the modern plant. Many small tools, such as portable drills, riveters, chipping tools, etc., operated by compressed air, form essential parts of the outfit, and the ability to take the tool to the work and perform minor operations directly under the hand of the skilled workman has practically given such workmen the opportunity of extending their personal skill far beyond the capacity of the hammer, chisel, and file with which they acquired it. Even in such a minor function as that of blowing away the accumulation of chips and dust beneath the cutting tool in the machine, the provision of a supply of compressed air throughout the shop has demonstrated its value, and the mere knowledge that a supply of air is "on tap," so to speak, suggests its application in many labor-saving ways. The modern caisson system for sinking foundation is dependent upon the air compressor for its existence, whether the work be on land or under water. The great bridge and the tall building depend alike upon the possibilities of the application of compressed air for their foundations and for the mechanical riveting of their structural-steel members.

All these applications of compressed air involve the design and commercial production of the machines by which the air under pressure may be economically produced, a department of engineering which demands knowledge and experience of the highest grade, both in the principles of thermodynamics and in the fundamentals of machine design. Different conditions demand machines suited to the special service required: the compressor must be adapted to the mine, the quarry, the workshop, and the portable equipment of the contractor; in short, it must be the product of familiarity with the mechanical, operative, and commercial conditions under which it has to be used, a familiarity which comes only from the combination of trained engineering skill with long experience.—*Cassier's Magazine.*

INVESTIGATING COMPRESSED AIR LOSSES

Some rather important points were brought up by Mr. W. L. Wotherspoon at the recent meeting of the South African Association of Engineers, in discussing the Meyer and Charlton Rock Drill Tests. Mr. Wotherspoon has had a large amount of experience in making power efficiency tests and in the compilation of statistics dealing with power production on the mines. He stated that he had gone into the air power problem some time ago and had attempted to make a fairly close computation of the air power on a large number of mines. The results of his investigations showed that on one deep-level mine they could carry on work successfully with from 50-60 per cent. less power per machine shift than a neighboring and similar property, and unless it could be proved that this large varying factor is justified for ventilation purposes, it must clearly be due to uneconomical working.

The matter calls for further investigation as it means that a very large proportion of the total power costs are effected. On a large property (say 200 stamps) the air power cost usually amount to from 1/3 to 1/2 of the total for the mine. This may represent £2,000 a month for air power, so that if only a 10 per cent. saving could be effected, it would amount to £2,400 a year on a single mine. Again, the duties of a rock drill fitter vary a great deal. On some mines he may have fifteen machines to keep in efficient repair, while on others twice the quantity may be under his supervision, and there is no doubt but that the cost entailed through more supervision would in many instances be more than justified.—*South African Mining Journal.*

AIR WASHING AND AN AIR WASHER

The presence of dust in the air of industrial, educational and other establishments, is recognized as inimical to health and otherwise highly objectionable, and increasing attention is being given to the problem of its elimination with most encouraging results as to its practicability. This general topic is interestingly discussed in a pamphlet about to be issued by the New York Blower Company, of Chicago.

Naure's method of removing these impurities, it says, is to collect moisture on each mite of dust until, combined with others, it forms a drop of sufficient size to fall to the earth of its own weight. Millions of drops make the shower, sweeping clear the atmosphere of multi-millions of particles, absorbing gases and creating that wonderful clearness which is a sign of the resulting purity. No dry process is used by nature and no artificial process can fully succeed in which dependence is placed upon screens of any type to merely hold the dust in dry form. They cannot be automatically cleaned and require periodic attention.

The real cleaning of the atmosphere is attained by the original attraction of the moisture by the dust particles. The washing effect of the descending drops is only an incident in the process. The cloud particles permeate the space in which they are, the raindrops are relatively few and far between. An atmosphere permeated with mist, water in its most minutely divided form, must be presented to the passage of the dust laden air. Each dust particle then becomes the center of attraction for the vapor particles, it is increased in size and weight, and the air becomes supersaturated with water held in mechanical suspension.

This excess of moisture must be created in order to grasp and hold the solid matter. But once caught these particles may be easily separated from the air and conducted away with their burden of objectionable material. Hence the extractor or eliminator, a device designed to remove the mechanically suspended particles which represent the excess of moisture. In a word supersaturation and extraction are the two essential elements in the cleansing and purification of air. The air leaving the extractor should retain no visible moisture; only that which has been absorbed and with which it is saturated. The temperature within the spray chamber should be such that when the air is heated during its subsequent passage through the main heater or flue heaters the relative humidity will be sufficiently reduced.

An accessory of the air washer is the primary tempering coil which is necessary for use during the winter season. By its means, under thermostatic control, the air entering the spray chamber is warmed to just the temperature best adapted to the action of the spray. Without such provision for pre-heating of the air the entire apparatus would become inoperative when the temperature fell below freezing.

The material of an air washer, subject as it always is to constant contact with moisture, should be uninjured by it. All metal work should be rustless. This requirement is best met by the use of brass and copper, and to a lesser degree by galvanized iron. Concrete should be substituted for wood.

NEW BOOKS

Compressed Air Plant for Mines, the Production, Transmission and Use of Compressed Air, with special reference to Mine Service by Robert Peele, Mining Engineer and Professor of Mining in the School of Mines, Columbia University, New York, John Wiley & Sons, 330 pages 6 x 9 inches, 112 illustrations. Price $3.00. This is a very complete, thorough and convenient presentation of practically all accessible and up-to-date information upon the general subject of compressed air, and should be of service to all users of compressed air whether in mines, quarries, tunnels and large engineering operations in general or in specific lines of service in manufacturing and elsewhere. All the familiar types of compressors are described and illustrated, their principles of operation and details of construction are discussed as are also those of the various air operated devices. The latter portion of the book is devoted to the several lines of employment of compressed air in practical mining, the equipment and operation of typical mines being given in considerable detail. The book is handsomely and effectively illustrated and completely indexed.

HIGH PRAISE FOR A TECHNICAL BOOK

The Engineer, London, reviewing a new book on The Modern Steam Engine, by John Richardson, discourses as follows:

The book before us has the great fact in its favour that it has been written by a man who has during the last forty years or so superintended the design and construction of over 25,000 steam engines of from 6 to 2000 indicated horse-power. The literature of the steam engine has been narrowed in its scope, because Mr. Richardson represents a class which cannot be induced to write books. He is a notable exception, and the volume before us is also exceptional.

* * * * *

The book is essentially a practicable treatise. *It is quite delightfully free from tables and formulae.* It is a standard example of how well an engineer can get on without the personal use of the higher mathematics. In his preface our author tells us: "For those students who wish to tackle very abstruse problems, needing the use of the higher mathematics, there are many suitable books already published, and to these such students are referred. Such a course of study is for the very few; the contents of this book are for the much larger class who, starting without knowledge, want to obtain a clear but comprehensive acquaintance with the steam engine."

* * * * *

Most forms of the steam engine are dealt with, but the most interesting part of this portion of the volume is perhaps that devoted to the design of details. Here is a thoroughly practical passage: "A good designer can do more to promote morality and prevent profane swearing in an engine factory than all the ministers and clergymen in the district."

Yours Truly
Gardner D Hiscox

DEATH OF GARDNER D HISCOX

Gardner Dexter Hiscox was born at Elizabethtown, N. Y., in 1822, and died at East Orange, N. J., on Sept. 6, 1908. He was in many respects an exceptional man and deserving of more than a passing notice, but material for a consecutive narrative of his career does not seem to be accessible. Born on Lake Champlain and amid rural surroundings he had no more than the usual education obtainable in the district school and the village academy of his time, which, however, afforded facilities for practical preparation for life's activities not to be spoken lightly of even to-day. Before he was out of his teens he was teaching school and soon thereafter he engaged in mercantile pursuits which he followed most of his active life. He was in business in Chicago when the fearful panic of 1857 occurred and brought his career to a close there. His longest consecutive business connection is understood to have been as a partner in a house in New York, manufacturing and dealing in steam and water fittings and supplies, and he became an expert and a leading authority upon steam heating, ventilation and sanitary engineering. His later years were spent in consulting and advisory engineering, in editorial work and in compiling technical books. He was connected with the Scientific American for many years and is understood to have been especially engaged there in conducting the technical question and answer department, for which he was eminently qualified. He was also a contributor to the Compressed Air Magazine from the first year of its existence. Mr. Hiscox was the victim of a serious trolley car accident some six years ago, which practically confined him to his residence for the rest of his days.

Mr. Hiscox was a man of exceptional and tireless mental activity. He perhaps had no special hobby, but he was an omnivorous collector of all available information in every line. He seemed to know much about everything and he was always glad to communicate anything that would help anybody. He was besides all else an amateur mechanic with a workshop of choice tools in which he spent many leisure hours with results of lasting excellence and value. He had an exceptionally fine microscope which he had built and a valuable collection of objects of his own preparation. He had also built a telescope and in connection with that he became incidentally the founder of the Brooklyn Astronomical Society.

The most enduring work of Mr. Hiscox is of course in his books. These, in the range of them, indicate the reach and versatility of the man. If any are disposed to speak of them as compilations rather than works of original and independent research and deduction, they must at least concede that the work he undertook to do in them was thoroughly done and they are of lasting value. The titles of his books are as follows: "Mechanical Movements," "Mechanical Appliances," "Gas, Gasoline and Oil Engines," "Twentieth Century Book of Recipes, Formulas and Processes," "Modern Steam Engineering," "Compressed Air in All Its Applications," "Hydraulic Engineering."

The Lagunitas Water Company has a plan of constructing a dam 110 feet high on the northwestern slope of Mt. Tamalpais and forming a reservoir which will impound 2,000,000,000 gallons of water to furnish a flow of 10,000,000 gallons a day to San Rafael and other towns. The Marin County Water Company, a rival, had bought up surrounding territory thinking it could make it unprofitable for the Lagunitas company to pipe a supply over the mountain. The latter company now proposes to construct a tunnel 8,000 feet long to bring water to prospective customers.

COMPRESSED AIR FOR HOISTING

Compressed-air hoisting engines should be fitted with extra large exhaust ports and pipes but should have small clearances, although the former may be dispensed with if the air to be used is reheated near the engine. A small amount of coke is all that is necessary for reheating, which prevents all danger of freezing besides effecting a decided saving. To obtain the best results, reheat the air near the place where it is to be used. The pipe for conveying the reheated air from the heater to the cylinder should be covered, as the loss of heat takes place rapidly. Live steam is a good reheater if available. Feed-water heaters give good results if the heating surface is ample and the air passage free. It has been estimated that ⅛ lb. of coke per horse-power per hour will effect a raise in temperature of 366 deg. and cause a saving of from 25 to 35 per cent.

The greatest efficiency in a compressed-air hoisting plant is obtained where a central compressing plant can be used to drive a number of different sized steam hoists located far apart, and necessitating a separate supply of water and fuel for each hoist, if there is no central heating plant. Such boilers scattered about a mine are wasteful of fuel and usually do not give an efficiency of more than 3 or 4 lb. of water for each pound of coal burned, while a central boiler plant will average an efficiency of 8 or 10 lb. per pound of coal. A compressed-air engine at the central plant is ready for instant, continuous service at full speed. No time need be lost in working out water or quickening fires and there is no loss of steam when the hoist is stopped while the boiler fire is hot.—*Engineering & Mining Journal.*

A TUNNEL RECORD

Engineering News, from data furnished by Mr. George F. Samuel, Assistant Engineer in the Department of Public Works, gives the following account of the progress of the work upon the southwest land tunnel of the Chicago waterworks.

While the tunnel is somewhat smaller than a railway tunnel, its maximum size is a horseshoe section 14 ft. x 13 ft. 8 ins., and it is in this section that the highest record has been made. The maximum monthly progress was made in June, being in drift 21 of Section No. 3. This record was 390 ft., made by working two groups of men in two ten-hour shifts. The daily average was 13.4 ft. for 29 working days. This work was under the direction of Mr. Daniel O'Conner, as Superintendent. The maximum daily average was 16.4 ft., made by the same force on June 30. The gang for each 10-hour shift was made up as follows:

1 Foreman
4 drillers
4 driller helpers
1 nipper
13 muckers
1 cageman
4 top men
1 compressor engineman
1 electrician and helper
1 blacksmith and helper
1 machinist and helper
1 powder man
1 pump man and helper
—
38 Total.

The excavation is carried on by a top-heading 9 ft. high kept about 12 ft. in advance of the bench, which is shot each day. For drilling the heading there are four Ingersoll-Rand drills mounted in pairs on two columns. Each set of holes consists of 8 cut holes 9 ft. deep, 6 helper holes 7 ft. deep, and 12 rim holes 7 ft. deep. The drills are then turned over on the columns and four bench holes are drilled. About 250 lbs. of 60 per cent. gelatine dynamite are used to make an average progress of 7 ft. The rock through which the tunnel is driven is a hard limestone. The length excavated to July 31 was as follows: Section 1, 18,841 ft.; Section 2, 18,880 ft.; Section 3, 1,168 ft.

NOTES

It is announced that the Rix Compressed Air and Drill Company, of which Mr. Edward A. Rix is President and General Manager, "in response to the call of the old machinery district has been moving." The office and salesroom will hereafter be located at 371 Market Street at Fremont, and the factory at 219-221 Spear Street, San Francisco.

Illuminating gas of ordinary composition when compressed, precipitates the heavier hydrocarbons in the form of liquid or tarry products, materially reducing the incandescent effect. The peculiarity of Pintsch gas is its remaining fixed under a compression as high as ten atmospheres. It is made from high grade petroleum distillate and has an illuminating power six times that of coal gas.

A mixture which gives good results in preventing the rusting of machinery is one ounce of camphor dissolved in one pound of melted lard. Skim off the impurities and add black lead to give an iron color. Clean the machinery carefully and apply the mixture, which may be left on indefinitely, or if wiped off in 24 hours will prevent rust for some time. Polish the metal with a soft cloth after removing the mixture.

A new machine shop and foundry is being erected for the Goldschmidt Thermit Company, 90 West Street, New York. The building, 34 by 90 feet, is located in Jersey City just back of the present factory of the company and it is to be fitted up with traveling cranes and other facilities for the better handling of the extensive repair work which comes to the works, such as electric motor cases, truck frames, gear wheels, crank shafts, and in fact any wrought iron or steel sections not exceeding a ton in weight.

A sheet of iron one foot square and one inch thick weighs 40 lb., or 640 oz. Therefore a sheet of iron one foot square and $^{1}/_{640}$ in. thick weighs one ounce. The scale has been arranged so that each number represents a certain number of ounces in weight, and an equal number of 640ths of an inch in thickness. The numbers range from 0000000, which weighs 320 oz. per square foot and is 0.5 in. thick, to 38, which weighs 4 oz. per square foot and is 0.00625 in. thick. An act of Congress requires that this gauge shall be used in determining the duties and taxes levied on sheet and plate iron and steel.

"Now, what is the matter with the machinery geniuses that none of them have ever invented a granite paving cutter? These fellows are certainly overlooking a bet, for such a machine could be devised without any radical new principle of mechanics being necessary. Undoubtedly, a better paving block than has ever been turned out could be made by machinery with considerable economy. There is a big bunch of grapes for the inventor who will heed this suggestion, and we know a large number of quarrymen who would like to purchase machines of this kind as fast as they can be turned out, after it is demonstrated that they can do the work."—*Rock Products.*

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

AUGUST 4.

894,813. CONCRETE-CONVEYER. Josiah W. Buzzell, East Orange, N. J. and William H. Larkin, Jr., Worcester, Mass.

894,818. ELECTRODE FOR THE EVOLUTION OF OZONE FROM OXYGEN OR ATMOSPHERIC AIR. John R. Craig, Jr., Glasgow, Scotland.

894,830. PROCESS OF TREATING AND HEATING AIR. Gustaf E. Hesse, Brooklyn, N. Y.

1. The method of continuously producing a motive fluid for driving an engine, which consists in delivering air under pressure and in a continuous manner into a chamber, delivering steam continuously into said chamber to thoroughly admix with the air therein, forcing the mixed air and steam under the initial pressure applied to the air from said chamber in the form of numerous confined thin tubes; continued for a suitable distance, into a collecting chamber having an outlet therefrom, and heating said thin tubes of moving mixed air and steam from the inner sides thereof during their passage to said collecting chamber.

894,831. APPARATUS FOR TREATING AND HEATING AIR. Gustaf E. Hesse, Brooklyn, N. Y.

894,852. BLOWING-ENGINE OR COMPRESSOR. Gustav B. Petsche, Philadelphia, Pa.

894,882. PISTON FOR AIR-PUMPS. Thomas R. Green, Riverside, Cal.

894,904. AUTOMATIC SPRINKLER SYSTEM. George I. Rockwood, Worcester, Mass.

895,084. AIR-COMPRESSOR OR VACUUM-PUMP. Elie Gaucher, Constantinople, Turkey.

895,192. APPARATUS FOR LIQUEFYING AIR. James F. Place, Glenridge, N. J.

895,292. BLOWING-ENGINE INLET-VALVE. Marvin A. Neeland, Youngstown, Ohio.

895,341. GRADUATING RELEASE-VALVE. John W. Cloud, London, England.

895,349. PNEUMATIC TOOL. Thomas Donohoe, Avella, Pa.

895,398. SUBAQUEOUS FOUNDATION. Albert F. Eells, Boston, Mass.

1. The method hereinbefore described of placing a hollow subaqueous base for piers, lighthouses and like structures, the same consisting in mounting said base, closed at the top, with its lower edge resting upon a temporary bottom, in forcing compressed air into the space within said base and bottom, and in sinking said base in place by releasing the air whereby the bottom is collapsed and the edges of the base sunk to the bottom of the water.

AUGUST 11.

895,426. PRESSURE - REDUCING VALVE. Frank T. Cable, Quincy, Mass.

895,438. PNEUMATIC CHUCK. Charles B. Delany, Columbus, Ohio.

895,543. PNEUMATIC CAISSON. Oliver C. Edwards, Jr., Troy, N. Y.

895,643. AIR-PUMP. Kirk G. Johnston, New York, N. Y.

895,693. DUST ARRESTER AND SLUDGER. Louis T. Sicka and John P. Collins, Butte, Mont.

1. In a rock drilling system, an air supply, an air operated rock drilling machine, a drill bit enlarged at the cutting end and operated by said drilling machine, a water tank, the top of which is flexibly connected to the air supply, a nozzle flexibly connected to the bottom of said water tank and adapted to be inserted in the drill hole behind the enlarged end of the drill bit, means for regulating the air pressure in the water tank, means for regulating the water discharged at the cutting end of the drill bit, said water tank being provided with an internaly concaved lower end for utilizing all the water in the tank.

895,735. TRAIN-PIPE COUPLING. William G. Felkner, Sebree, Tex.

895,750. HOT-AIR PIPE. George Harms and Charles Spindler, Peoria, Ill.

895,798. AUTOMATIC APPARATUS FOR GAS ANALYSIS. Emil Schatz, Frankfort-on-the Main, Germany.

895,877. ROCK-DRILLING DEVICE. Eugene E. Messmore, Epworth, Iowa.

895,962. APPARATUS FOR COOLING AIR. Confucius Chase, Boston, Mass.

895,984. PNEUMATIC HUB. John Duchan, Elizabethport, N. J., and Roland Duchan and Johann Duchan, Vienna, Austria-Hungary.

895,994. AIR-CUSHION FOR HORSESHOES. Jacob H. Fawkes, Detroit, Mich.

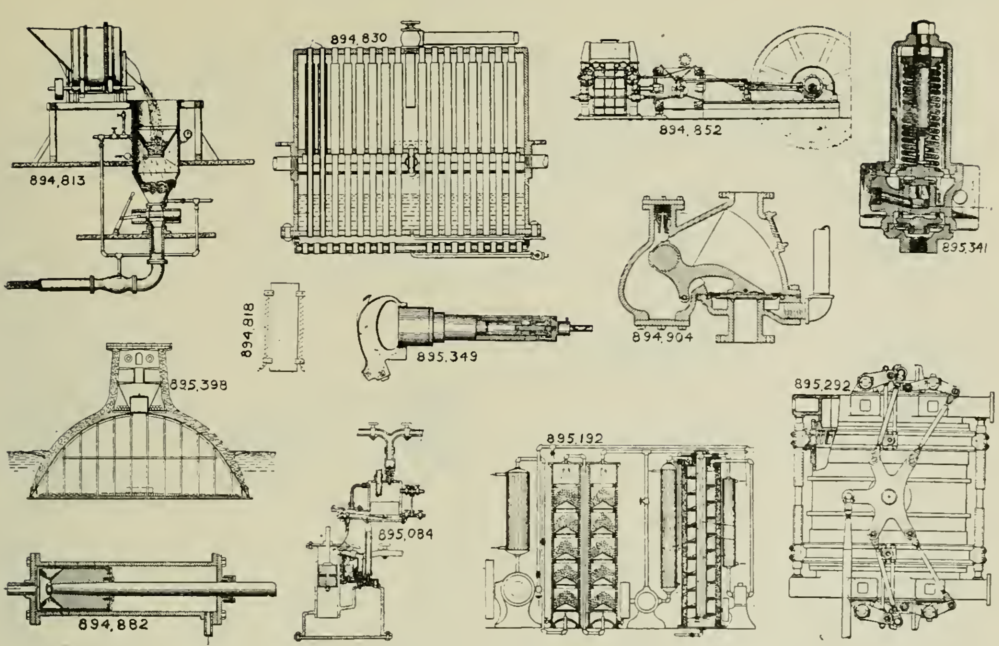
1. A device of the class described, comprising a shoe adapted to be secured to the hoof of the horse, a clamping ring fitting within the shoe, screws traversing the clamping ring and engaging the shoe, a resilient bag fitting within the clamping ring, a flexible cover fitting over the bag and having its edges inserted between the clamping ring and the shoe, an air receptacle arranged as a seat for the rider or driver, and tubes connecting the resilient bag with the receptacle.

AUGUST 18.

896,148. SPRAYING DEVICE. Adelbert M. Phillips, Le Roy, N. Y.

896,212. AIR-ACTUATED RAILWAY-FENDER. Smith S. Johnson and Henry A. Thompson, Seattle, Wash.

696,290. PNEUMATIC DUST - REMOVER. Miles E. Freeman, Bradford, Pa.



Pneumatic Patents, August 4.

A nozzle for a pneumatic carpet cleaner, having parallel walls and an apertured diaphragm within its interior, and provided with a tongue extending parallel with the walls of the nozzle and which divides the nozzle into a plurality of compartments and extends from said diaphragm outwardly.

896,365. GAS-CLEANER. Alfred Ernst, Pittsburg, Pa.

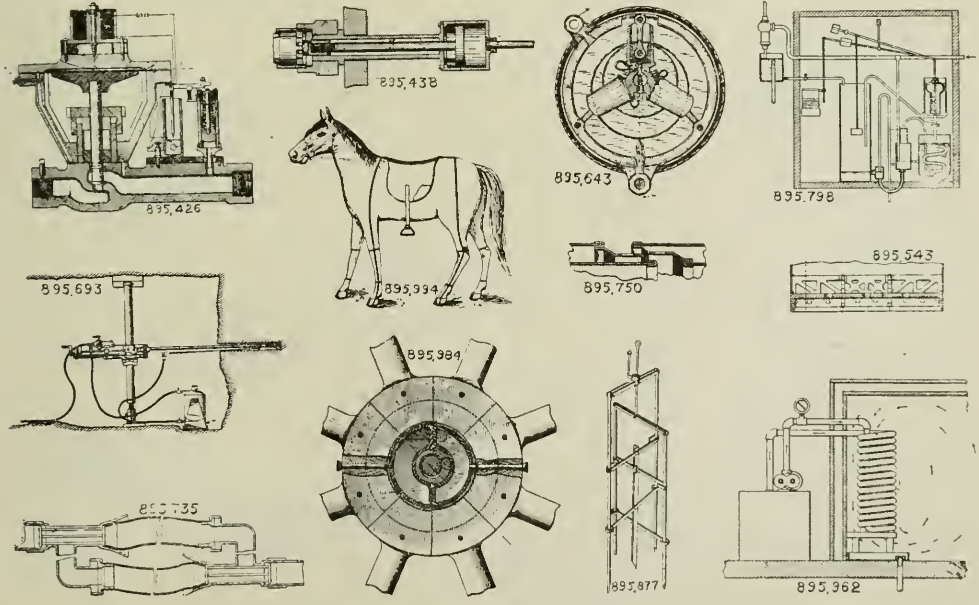
896,447. AIR REGENERATING AND PURIFYING APPARATUS. Sydney S. Hall and Oswald Rees, Portsmouth, England.

896,475. ROCK-DRILL. Clark J. Smith, Ottumwa, Iowa.

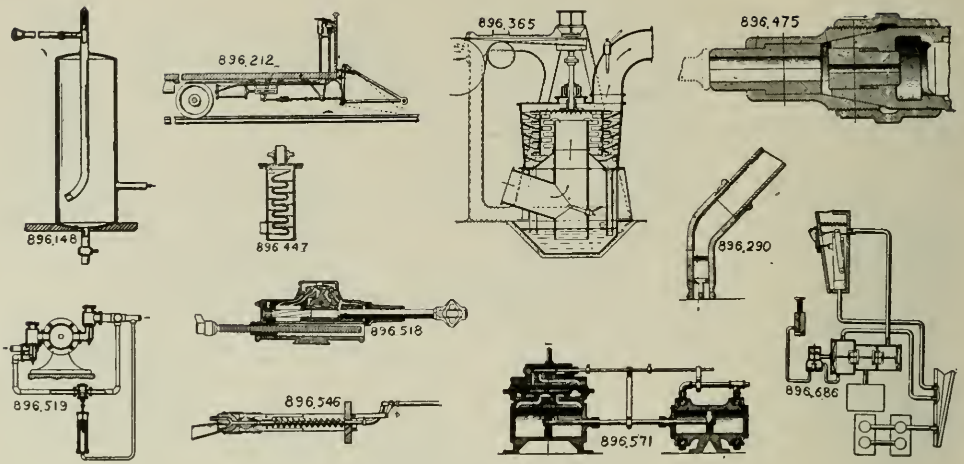
896,518. ROCK-DRILLING MACHINE. John B. Damas and Josph Francis, Sonora, Cal.

896,519. APPARATUS FOR MIXING GAS AND AIR. Erich Dankelmann, Berlin, Germany.

896,546. AUTOMATIC AIR-PIPE COUPLING. Frank Hunter, Trinidad, Colo.



Pneumatic Patents, August 11.



Pneumatic Patents, August 18.

896,571. COMBINED HYDRAULIC MOTOR AND AIR-COMPRESSOR. George E. Ocain, Oak Park, Ill.

896,686. VARIABLE-TENSION EXPRESSION-BELLOWS FOR PNEUMATIC APPARATUS. George P. Brand, New York, N. Y.

AUGUST 25.

896,777. GAS-OPERATED ROCK-DRILLING ENGINE. Rolland S. Trott, Denver, Colo.

896,823. PRESSURE-MAINTAINING SYSTEM. Frank Gray, Chicago, Ill.; Catherine Helen Gray and Clarence Gray, executors of said Frank Gray, deceased.

896,854. TRAIN-PIPE COUPLING. Albert S. Parsons, Berkeley, Cal.

896,902. TIRE-PUMP. Julius A. Dyblie, Joliet, Ill.

896,933. AIR PUMP OR INFLATOR. Frederick S. Nickells, London, England.

896,956. APPARATUS FOR MIXING FLUIDS. William F. Traudt, Passaic, N. J.

896,958. HIGH-PRESSURE BRAKE. Walter V. Turner, Wilkinsburg, Pa.

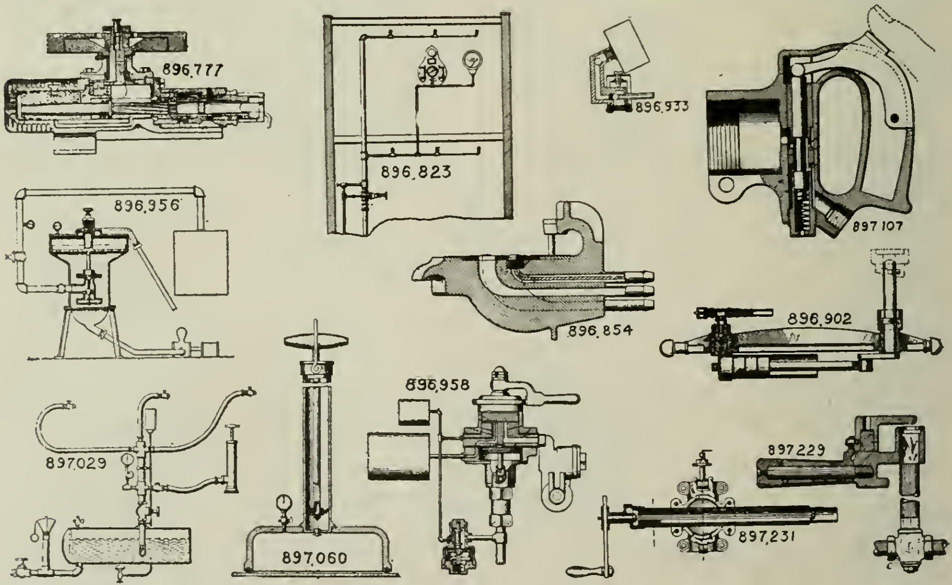
897,029. SPRAYING APPARATUS. Hilldreth F. B. Snyder, Mosier, Oreg.

897,060. LIFTING DEVICE. Robert W. Cash, Hannibal, Mo.

897,107. PNEUMATIC TOOL. William H. Keller, Philadelphia, Pa.

897,229. MECHANISM FOR CONTROLLING AIR AND SAND ON CARS. Claude Spicer, Elyria, Ohio.

897,231. AUTOMATIC FLUID - ACTUATED FEED MECHANISM FOR PERCUSSIVE TOOL. Daniel S. Waugh, Denver, Colo.



Pneumatic Patente. August 25.

COMPRESSED AIR
MAGAZINE
EVERYTHING PNEUMATIC.

Vol. XIII NOVEMBER, 1908 No. 11

READY OXYGEN MAKES ACETYLENE OPPORTUNITY*

By Cecil Lightfoot.

The application in the United States of the oxy-acetylene blowpipe to the welding of metals has not been developed at present to anything like the same extent that it has in England and on the Continent of Europe. This is no doubt because until within a comparatively few months there existed no satisfactory source of supply of the necessary oxygen. To some extent the absence until quite recently of any by-laws regulating the traffic in compressed oxygen and its transportation by rail, with the difficulty in cases of getting the traffic accepted at all, no doubt discouraged any serious effort to develop the trade.

Oxygen could certainly be obtained in most cities in the country, but its price was prohibitive for industrial application, while in most cases its purity was as equally problematical as nebulous. At that time the general practice in this country was to compress the gas to a pressure of about 250 pounds per sq. in. into riveted and brazed cylinders of steel or wrought iron, of diameter relatively large compared with the length. It is, however, essential that for economical results to be obtained on an industrial basis, the gas should be compressed to a higher pressure, as is now universally and without exception adopted in Europe, the construction of the cylinders being modified accordingly.

When in 1897 Dr. Carl von Linde succeeded in separating the constituents of the atmosphere by means of his method of air liquefaction and subsequent rectification, the solution of the problem of how to produce pure oxygen in large quantities and at a low price was realized. Now that the railroad companies have at length officially recognized the traffic in cylinders of oxygen under high pressure by the adoption of suitable regulations for its control, and with the establishment on an extensive scale of an oxygen plant by the Linde Air Products Co. at Buffalo with an output of many thousands of cubic feet a day, great impetus has already been given to the application of the oxy-acetylene blowpipe in this country. In fact, the development which has taken place in the past month or two has been most remarkable, and it may be predicted with certainty that welding by means of the oxy-acetylene blow-pipe will ultimately become a very important factor in mechanical engineering practice, and will be developed on a scale far exceeding anything that is now being done in Europe. It is almost possible to foresee the time when every machine shop and engineering establishment of any magnitude will be equipped with an oxy-acetylene welding plant.

Oxygen may, of course, be generated by chemical means on the spot, and indeed there are at the present moment a number of such small chemical plants in daily operation, with more or less success, in conjunction with oxy-acetylene welding equipments. A somewhat complicated and frequently uncertain chemical process is obviously entirely out of place in an engineering establishment, and it would seem that, other things being equal, it is far more rational for supplies of oxygen to be obtained, ready for use, from some outside source. Apart from the space occupied by such a chemical plant to produce oxygen, there are other disadvantages, among which may be mentioned the trouble of periodically cleaning out and recharging the retorts and the oxygen producing plant, necessitating a continual expenditure for labor, besides the wear and tear of the parts themselves, due to corrosion and burning out. In some cases, also, there is a very objectionable refuse to be disposed of. Furthermore, it must be borne in mind that the oxygen thus produced is by no means pure, and requires filtration and scrubbing before it can be used. It has then to be compressed, necessitating not only some source of power but a continual repacking and renewal of working parts from time to time.

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*Proceedings International Acetylene Association, Chicago, August, 1908.

It is true that attempts have been made, so far without very marked success, to generate oxygen under pressure by chemical means, but it is obvious that the results obtained in this way must be uncertain, apart from any question of risk. The possibility of the deterioration of the raw material with age and exposure must also be taken into consideration, this being quite an important factor in many cases.

It will thus be seen that the generation of oxygen by chemical means is a considerably more involved process than the production of acetylene, and it is self-evident that unless oxygen can be obtained ready for immediate use without the complications attendant on the running of a chemical plant many engineering establishments will have diffidence in taking up the welding process.

Recognizing all this and that there must be a growing demand for oxygen if it can be supplied to the consumer under high pressure ready for immediate use and in a convenient and portable form, the Buffalo works of the Linde Air Products Co. have been established on a very large scale indeed. With an equipment of cylinders which runs into many thousands the company is now prepared to supply every possible demand.

The oxygen supplied by this company is guaranteed to contain not less than 95 per cent. of pure oxygen, the balance consisting of the ordinary nitrogen constituents of the atmosphere. It is shipped under high pressure in solid-drawn, seamless steel cylinders of special construction which comply with the amended railroad classification regulations. For industrial application the largest size of cylinder, which contains 100 cu. ft. of oxygen under a pressure of 120 atmosphere, is most convenient. Furthermore, with a view to minimizing the delay arising from long freight hauls and insuring prompt delivery of cylinders containing compressed oxygen the company have introduced an "exchange-sale" system. For the convenience of the company's clients who have purchased cylinders from them—thereby obtaining the benefit of reduced rates and avoiding rent charges—the company will, if so desired, supply "full" cylinders on receipt of bills of lading covering the return of an equal number of similar "empties," providing the latter have been despatched freight prepaid.

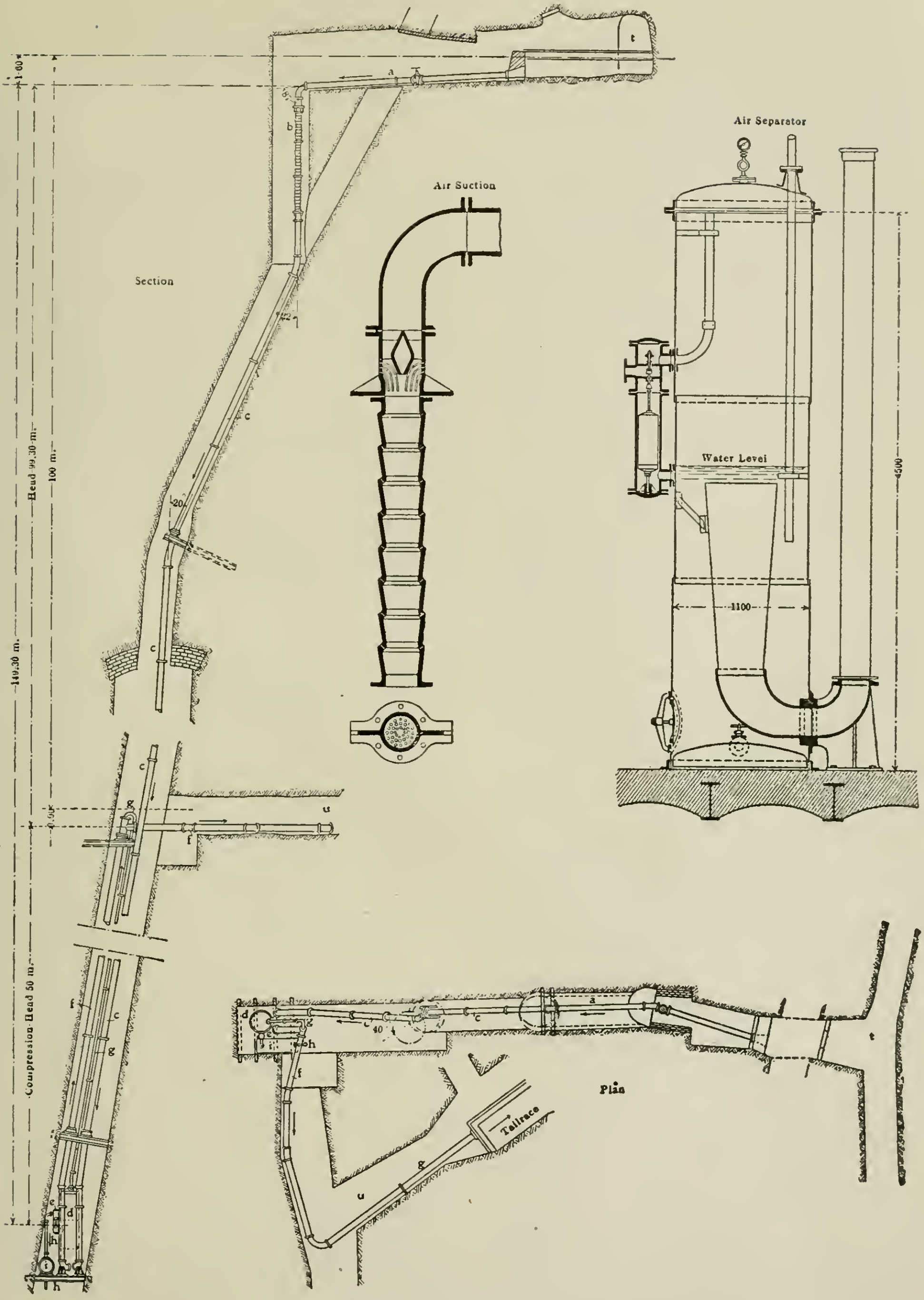
HIGH EFFICIENCY OF A HYDRAULIC AIR COMPRESSOR

P. Bernstein in *Glückauf* describes and discusses the operation of a hydraulic air compressor recently installed in one of the mines at Clausthal. It replaced a piston compressor driven by a Pelton wheel, and effected a marked saving in running expense. For the following abstract we are indebted to *The Engineering and Mining Journal.*

The arrangement of the apparatus is shown in the accompanying illustration. A flow of water in the tunnel, *t,* is led through the cast-iron pipe, *a,* of 218 mm. diameter, to the air suction pipe, *b.* With the entrained air, the water then flows through the cast-iron pipe, *c,* 218 mm. diameter and 150 m. long, which is laid, somewhat crookedly, down an inclined shaft. The water discharges into the bottom of the receiver *d,* 1.1 m. diameter and 4.5 m. high, which rests upon an I-beam support in the shaft at a depth of 52 m. below the level of the overflow tunnel at *u.* The receiver is provided with a pressure gage, and a pipe, *g,* which passes up parallel to the discharge pipe and enters it at the discharge level.

The compressed air escapes through the valve, *e,* passing then into the reservoir, *i,* and thence, through the 80-mm. pipe, *h,* to the working places of the mine. The overflow water passes up through the pipe, *f,* 218 mm. diameter and 50 m. long, to the level *u.* The construction of the component parts of the apparatus is shown in the drawing. By the peculiar construction of the air inlet, which creates no compression of the water, and by the avoidance of sharp corners, the loss of head through resistance is reduced to a minimum.

The average flow of water through the system was found to be 3 cu. m. per min., which falling through the distance 99.3 m., between the intake and the discharge levels, yielded



CLAUSTHAL HYDRAULIC AIR COMPRESSOR.

3000 kg. x 99.3 m., ÷ 4500 kilogram-meters per min., or 66.2 h. p. In order to test the efficiency of the installation, at full capacity, a test was made during which the flow of water was measured by a weir, and the amount of compressed air was measured by the filling of a receiver of known capacity. It was found that 3.2 cu.m. of water per min., falling the 99.3 m., afforded 10 cu.m. of air per min., at an effective pressure of 5.1 atmospheres (90 lb. abs. per sq. in.). The work required to compress 1 cu.m. of air, adiabatically, to 5.1 effective atmospheres is approximately 24,300 kilogrammeters, so that, under the above conditions, the compressor was performing 10 × 24,300 ÷ 4500, or 54 h.p. The theoretical power of the water was 3200 × 99.3 ÷ 4500, or 70.5 h.p., showing an efficiency of 77 per cent.

The Pelton wheel had an efficiency of about 75 per cent., including in the computation the water, 4 or 5 liters, used for cooling the compressor, and the compressor had an efficiency of 85 per cent., so that the combined efficiency of the installation that was displaced by the hydraulic apparatus was only 64 per cent., as against 77 per cent. efficiency of the new installation. Assuming the same conditions as in the above mentioned test, the older combination of machines would have yielded only 0.64 x 70.5 x 4500 ÷ 24,300, or 8.3 cu.m. of air per minute.

The superiority of the hydraulic installation is seen not alone in the greater capacity and efficiency. In the following tables are compared the cost of compressing air by three different means, viz., (1) by a piston compressor, belt-driven from a water turbine consuming the same amount of power as the hydraulic plant. (2) By an electric-driven compressor of the same capacity and using the same amount of power as the hydraulic plant. (3) By the hydraulic installation itself.

1. *Water-driven Plant*

Investments:	
Belt-driven compressor	$1,250
Pelton wheel, complete	1,125
Building, foundations, etc	450
	$2,825
Interest and Depreciation:	
Interest on plant at 5 per cent	$ 141
Depreciation of machines at 10 per cent.	238
Depreciation of building at 3 per cent.	15
Operating expenses:	
Wages (night and day shifts)	600
Lubricants, ½ pound per hour	75
Repairs and waste	75
Total annual expense	$1,144

Assuming 6000 working hours per year, and an output of 7.8 cu.m. per min., the year's output by the above arrangement would cost $0.38 per 1000 cu. meters.

2. *Electric-driven Plant*—Assuming the efficiency of the compressor to be 0.90, of the belt or gear drive, 0.95; of the motor, 0.90; and of the current transformer, 0.950; the total efficiency of the electric-driven plant would be 73 per cent., and for the exertion of 54 h.p. would require the purchase of 74 h.p. from the central generating station.

Investments:	
Belt-driven compressor	$1,500
Electric motor, 70 h.p.	1,200
Buildings, foundations, etc	450
	$3,150
Interest and depreciation:	
Interest on plant at 5 per cent	$ 158
Depreciation of machines at 10 per cent.	315
Depreciation of building at 3 per cent.	15
Operating expenses:	
Wages (day and night shift)	600
Lubricants	95
Repairs and waste	100
Electric power, 74 h.p. for 6000 hr. at ½c. per h.p.-hr.	2,220
Total annual expense	$3,503

With an output of 10 cu. m. per min., the year's output by the above arrangement would cost $0.98 per 1000 cu. meters.

3. *Hydraulic Compressor*—

Investment:	
Compressor, installed	$3,750
Interest and depreciation:	
Interest at 5 per cent	187
Depreciation at 5 per cent	188
Operating expenses:	
Lost wages during shutdowns	30
Repairs	20
Total annual expense	$425

With an output of 10 cu.m. per min., the year's output by the hydraulic compressor cost only $0.12 per 1000 cu.m. It may be added that 10 cu.m. of air at 5.1 effective atmospheres is equivalent to 353 cu.ft. at a pressure of 90 lb. abs. per sq. inch.

RESPIRATION AND ATMOSPHERIC IMPURITIES

Mr. W. Thomson, before the Manchester and Salford Sanitary Association, recently described a series of experiments to ascertain the amount of carbonic acid in the air in Manchester (England), and in various buildings under different conditions. He was led to made these experiments by a request for some simple device for estimating the carbonic acid gas in public and other buildings. The method he recommended was that of forcing air into a bottle with an ordinary pair of bellows and submitting it to a simple chemical test.

FOUL AIR IN MANCHESTER BUILDINGS.

Mr. Thomson gave the results of the analyses of air taken in a number of schools in and near Manchester. For purposes of comparison, he took the amount of impurity that is accepted by modern architects as permissible in buildings—viz., six parts of carbon dioxide in 10,000. Samples of air taken in Macclesfield schools by Mr. Horsfall contained 1.4, 3.5, and 6.1 parts of carbon dioxide in 10,000. Air taken in some Manchester schools yielded proportions of carbonic acid gas as follows:—St. Matthew's, Deansgate (boys), 11.2; St. Stephen's, Hulme, 14.9 (girls) and 11.7 (boys); Crumpsall Lane School, 12.8 in one room and 8.3 in another; while in a school at Openshaw there was 18.2 in the boys' room and 11.5 in the girls'. In the Technical School there was 6.5. This building, Mr. Thomson said, was one of the best-ventilated in the city, but its atmosphere was objectionable to many people on account of its lack of invigorating qualities. He thought this was due to the method of washing the air.

In a Methodist Free Church near Manchester the air after service contained no fewer than 44 parts of carbonic acid gas per 10,000 volumes. Tests made in a large concert hall in Manchester showed 5.2 before a performance and 11.2 after one and a quarter hour. Tests in the Manchester Art Galleries gave 10.3 in one room and 8.6 in another. Three railway compartments yielded 12, 5.6, and 21.5. Air in a Manchester tram, 7.2. Old-fashioned houses with low ceilings in the country gave figures ranging between 5.6 and 12.5; new houses between 5.9 and 10.4, and a good sized room that had contained four persons and three gas jets for 1½ hour, 22. The carbonic acid gas in the air of one of the Manchester theatres before the performance was measured as 5.9, and after the performance, in the dress circle, 19.2.

HUMAN EXHALATIONS.

From these tests Mr. Thomson proceeded to find out the amount of carbonic acid gas exhaled in the breath of different people under different conditions. The amount of carbonic acid in the breath was given, he said, in books on physiology as about 4 or 5 per cent. The results of his experiments showed that the amount of carbon dioxide which a man breathed out depended upon the quality of the air by which he was surrounded. In Manchester he breathed about 4 per cent., and in the country 5 per cent., so that it would appear to be necessary to take about one-fourth more food in the country than was sufficient in town. The breaths of three men were tested. In Manchester the percentage of carbonic acid gas given off by each was—A 4, B 3.8, and C 4. At the Buxton golf links, 1,000 feet above sea level, the figures were 5, 5.2, and 5.2, and after they had played eighteen holes and had lunch they each gave 4.8 per cent. They then drove to the Cat and Fiddle, 1,700 feet above the sea and there A gave 5.2, B 5.4, and C 5.4. These results suggested that the amount of carbonic acid gas exhaled was influenced by altitude. But a test made at Blackpool did not sustain the theory. Further experiments showed that when a person went from Manchester to the country it had the effect of increasing the amount of carbonic acid exhaled to a percentage higher than that found in the case of people permanently residing in the country.

WHEN AIR IS HEATED.

He found, too, that when the air was inhaled through the mouth the breath was about .2 per cent. lower in carbon dioxide than when the nostrils alone were used. This was suggested to him that if the air were artificially heated a still greater oxidization would take place in the body. Air heated to 140 centigrade was breathed, and the exhalation contained 5.4 per cent. of carbon dioxide, whereas exhalation of ordinary unheated air from the same person gave 4.4. The average in a number of experiments gave 4.1 from ordinary air and 5.1 from heated air. When pure oxygen was breathed the exhaled air gave an average of from 4.4 to 4.5, which was considerably below what one got from breathing in the country. It would appear, therefore, that country air was better for reviving people who had been asphyxiated or nearly drowned than pure oxygen, and that a maximum effect would be obtained from warmed country air and oxygen combined. It was found, however, that the hot air breathed in a Turkish bath had not the same effect as hot air breathed when the body was only at its normal heat.

DRY AND DAMP AIR.

Experiments were also made as to the effects of dry and damp air, and it was discovered that thoroughly dried air has a much more powerful oxidizing influence on the blood than air that has not been dried, and that this effect is increased by heating the air. This, Mr. Thomson suggested, was an important fact to consider when arranging the ventilation of buildings. Many people had noticed, he said, that the air of the House of Commons had a peculiarly flat taste. It was not invigorating, and the people who sat in the House suffered considerably from influenza. This was due to the fact the air forced into the House was washed in water.

CENTRAL COMPRESSED AIR SCHEME FOR SOUTH AFRICA

[The following we take from a recent issue of the South African Mining Journal. The general lack of economy in contemporary compressed air practice on the Rand and the large demand for power within a limited area there seem to afford unusual opportunity for the scheme here proposed to make a favorable showing. Further developments will be looked for with interest.]

Ever since central power stations were first mooted on the Rand far-seeing engineers have been debating the possibility of extending the principle of centralisation to our costly and admittedly inefficient compressed air plants. To-day we are in a position to announce that a scheme to establish central air stations, which has been two years in the making, is on a fair way to be definitely realized at an early date. With its power supply plans, the newest centralized electric power company proposes to include compressed air, the object being, of course, to relieve the mines from any and every necessity to generate either form of power for themselves by the comparatively extravagant and old-fashioned methods of to-day. What one power supply company can do no doubt the other companies can and will do also. Beyond the discussion of the matter, the other power supply people do not appear to have yet done anything in the matter.

To-day the resident engineer of the mine is largely responsible for the generation of the whole power supply. He is less anxious in regard to the total power consumed than he is in regard to the cost per unit of that power. The reason for this is simply that his figures under the latter head are capable of direct comparison with the average and other figures of the Rand; while no real comparison can possibly be drawn between the wastage, leakage and general loss of power on the various mines. For this reason, if no other, considerable economies are likely to attend the introduction of a purchased air power supply which can be measured exactly on each mine. The same argument applies with equal force in favour of purchased electric power.

THE NEW SCHEME.

The engineering features of the new scheme are full of interest. Naturally in several particulars the world-renowned Paris compressed air system will be followed in the design of the plant. In many respects, however, the Paris plant will be improved upon and advantage taken of the discoveries of modern practice and research. The Paris plant is driven by steam power. The Rand plant will be driven by electric power drawn from a central power station. The compressors will be of 5,000 h. p. capacity each, three-cylinder, two of low pressure, and one of high. Each compressor will have two 2,500 h. p. motors directly connected to its crank shaft. The motors will be coupled together, so that they can run at full or half speed without altering the number of the poles. Any variation in output of air required below these two variations of speed will be dealt with by means of inlet valves of the Corliss type, operating by trip gear controlled from air pressures. In view of the experiments now in progress on the mines to determine the utility of high air pressures, the compressors will have a working pressure of from 80 to 110 lbs. per square inch, the pressure between these figures being dependant, of course, upon the requirements of the mines. The intention is to start with two chief stations on the Central Rand—one being situated in the Fordsburg neighbourhood; the other at a point half-way to Germiston. Later, as other areas develop, additional stations will be put down at central points. All these stations will be operated from a central electric power station. In the light of recent local investigations into the question of airpipe dimensions, it is noteworthy that the pipes to be used on the proposed scheme will vary from 28 inches down to 11 inches in diameter. Joints will naturally receive much attention. These will be electrically welded—no flanges; no threaded socket couplings; no expensive expansion joints. The air will be measured by meter at the mines, and the latter will pay by weight for the amount consumed—power actually used, of course, only being charged for.

ELECTRIC VS. AIR POWER TRANSMISSION.

To the layman, though not to the engineer, it will be news that it has been proved over and over again that it is cheaper to compress air direct at a central station and convey it by pipes to the various mines, than simply to supply electric power on the mines to drive the various compressors. In the latter case it has been found that the cost of plant is greater, and the losses in transformation heavier. At one time, it was considered more economical owing to saving in the outlay on pipes and the maintenance of a uniform pressure in the mine to transmit the air at very high pressure—200 lbs. and upwards—to receivers at a sub-station capable of storing energy for a large number of drills for an hour, and then to reduce the pressure by means of reducing valves before entering the service pipes to the mines to the usual working pressure. This method has been considered in the present case, but in the light of recent practice, rejected.

It is generally believed that electricity has a much superior advantage over compressed air for transmission purposes, that is, that there is a much smaller loss of energy over electric wires than through pipe lines. Compressed air has been badly misrepresented in this respect; this loss has been greatly exaggerated, and the catalogues of air-compressing machinery companies have not improved matters; in fact, they have done more harm than good as regards the interests of compressed air. The tables published in air compressor catalogues usually speak only of the loss of pressure; they fail to tell us that the loss of pressure is not necessarily, or to the same extent, a loss of power. As Frank Richards, in his work on "Compressed Air," says: "The actual truth is that there is very little loss of power through the transmission of compressed air in suitable pipes to a reasonable distance, and the reasonable distance is not a short one. With pipes of proper size and in good condition, air may be transmitted, say, ten miles, with a loss of pressure of less than one pound per mile. If the air were at 80 pounds gauge or 95 pounds absolute upon entering the pipe, and 70 pounds gauge or 85 pounds absolute at the other end, there would be a loss of little more than 10 per cent. in absolute pressure, but at the same time there would be an increase of volume of 11 per cent. to compensate for this loss of pressure, and the loss of available power would be less than 3 per cent. With higher pressures still more favorable results could be shown." As a competitor with electricity in long distance transmission, it seems almost like scientific heresy to claim for it equal if not greater efficiency; nevertheless it is claimed that within the 20-mile limit [10 mile radius? Ed. C. A.] compressed air will compare in efficiency with electric transmission, while so far as operating and maintenance expenses are concerned, the electric proposition is not to be compared for a moment with that of air. Over 15,000 h. p. of mechanically compressed air is distributed to-day throughout the city of Paris, being transmitted for a series of stations from three to fifteen miles distant, with a loss of 10 pounds pressure in transmission.

CHEAP ELECTRIC POWER.

An essential requisite of a successful central air-compressor scheme is cheap electric power. The guarantee of this in the case of the Rand assures the commercial success of the project. It also points to the fact that only those electric power companies that are in a position to supply electric power at an extremely low figure can engage in the sister-business of compressed air power supply. With compressed air available along the Reef, it is possible that this agency may be used for many purposes in addition to driving rock-drills. The multiplicity of uses to which it is put in Paris, and the fact that it is a harmless medium of power transmission, when compared with electricity, makes it worth attention in this connection. The essential fact is that the new system will mean a great saving to the mines, directly and indirectly, better air pressures, more scope for resident engineers to study economy, and in the last resort, improved results for shareholders. And the promoters of the scheme can congratulate themselves on the fact that theirs is an idea which the best engineering brains of the Rand have pondered and recommended for many a long day.

COMPRESSED AIR FOR CLEANING GAS CONDUITS*

By W. D. Mount.

Three years ago, the writer had occasion to ask for proposals on a battery of gas producers, including the design of the distributing conduit and branches.

As the producers were to supply gas to furnaces in continuous operation over long periods, which, for efficient working, required very uniform conditions of heating, the question of an uninterrupted flow of gas of uniform quality became of exceptional importance. We found that all of the builders of producers could, in a general way, meet the conditions of uninterrupted service; that is, it would be necessary to shut the gas off a few hours once each week, and clean the accumulated soot out of the conduits.

Our idea of continuous service was somewhat different. It did not mean shutting down once a week, or once each month, but meant a condition of operation absolutely without interruption for an indefinite period, and we finally made this a condition of our acceptance of the contract.. The distributing conduits had to be designed to meet existing conditions of space and apparatus in a department already so much overcrowded that a duplicate system of conduits, one to be in use while the other was being cleaned, was entirely out of the question.

In placing the contract, our decision was not based altogether on the merits of the different producers offered, but largely on the method or system of cleaning, and a design of distributing conduits which seemed to provide the greatest facilities for meeting the imposed condition of uninterrupted service. After carefully canvassing the designs submitted, a contract was placed with the Morgan Construction Co., of Worcester, Mass., through their engineer, Mr. E. A. W. Jeffries, M. Am. Soc. M. E., who, to quote from one of his letters, was confident a method of cleaning the conduits, which, because of conditions imposed, was the most important function to be provided for adequately, could be worked out, but which required special study, and which involved some features not heretofore fully developed.

I may say, at this point, that the congested condition of the department in which the producer plant was to be installed, as well as the location of existing apparatus, precluded the possibility of using underground conduits, and made it necessary that an overhead system be adopted.

The plan of action arranged for, as outlined by Mr. Jeffries, consisted in providing facilities in the way of openings in the conduit for blowing depositions of soot through into the stack, by means of steam jets, connections to the base of the stack being arranged for from each distributing conduit. The above outlined operation was not to occupy more than 15 minutes, during which time the gas was to be shut off, but the heat in the furnace was not to be seriously impaired. The condition of uninterrupted service, it is to be noted, was not fully met, and the writer was confident at the time, and subsequent developments proved his prediction to be correct, that when the gas was shut off, even though as small an amount of time as 15 minutes, it meant shutting off the product from the furnaces, or, in other words, it meant an absolute shut down of the department during the operation of cleaning.

The producers and distributing conduits, however, were installed as designed, and the proposed method of cleaning put into effect, with the exception that compressed air was used in place of steam. Measured by experience gained, the method was a great success, but as a means of keeping the gas conduits clean, it was a failure.

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*Presented at the Detroit meeting (June, 1908), of the American Society of Mechanical Engineers. (Somewhat abridged.)

It did not take long, however, to determine that the idea was all right, and that our lack of success was due to the fact that the facilities provided in the design for applying the air or steam were inadequate, as well as improperly located.

The experience gained in the early days led finally to the development of the system to its present form, which is fully detailed in the accompanying sketches, and which I am glad to report, has been so successful that for the past 18 months we have never for a moment had the gas shut off from our distributing conduits for the purpose of cleaning out the depositions of soot. The method and apparatus, as will be noted from the drawings, are extremely simple, and quite out of proportion to the results obtained.

COMPRESSED AIR A NECESSITY.

We have so much confidence in compressed air that we are almost inclined to believe that it is one of the things essential to the successful operation of the method, another being accessibility to the main conduit and its branches. The air should be thoroughly dry and at not less than 80 lbs. pressure. We find in practice that the connections from the conduit to the base of the stack are, for cleaning purposes at least, entirely unnecessary. The only time they are used is in making repairs on the conduits, when they are opened for the purpose of drafting out the gas. We also find that about 75 per cent. of the soot is deposited in the drop legs immediately behind the producers, the balance being dislodged by means of the air jet from the brick lining and carried along with the current of gas to the furnaces where it is almost wholly consumed.

Referring to Fig. 1. A A are openings in specially designed castings (see detail A, Fig. 2) spaced along the top of the conduit, and of the same depth as the brick lining. C is a cast-iron ball of a diameter sufficient to close the opening in A and free to slide on the ½-in. bent pipe B (see detail of C) which is connected by hose to the air main, a 1-in. pipe serving also as one of the hand rails along the top of the conduit.

The openings A A are spaced at a distance nearly equal to the diameter of the conduit (although this spacing is not necessarily fixed), which we have found by experience to be about right for effective work, and in any event they should not be at a distance exceeding 6 ft.

The bent pipe B should be long enough to reach all parts of the conduit from A to A. The pipe, however, for convenience in handling cannot be over 8 ft., and its length, therefore, in a measure, fixes the distance from A to A. Permanently attached to the end of the pipe is a short length of air hose, having attached at the other end the male portion of a standard ½-in. Joy coupling. Located along the hand rail air pipe, at distances from two to three times the distance between A A, are cocks and the female portion of the Joy coupling. Attaching the hose to the air main, therefore, is a very simple matter and consumes a minimum of time.

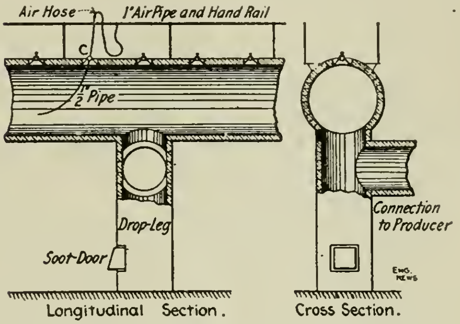


Fig. 1. Main Gas Conduit Arranged for Cleaning While in Operation.

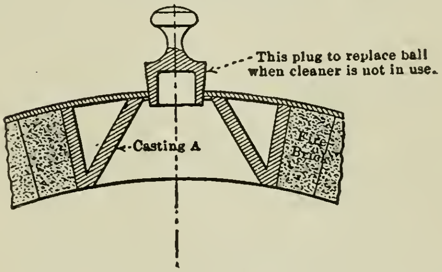


Fig. 2. Cleaning Hole Casting.

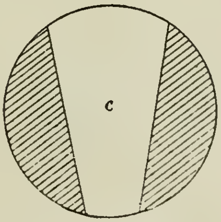


Fig. 3. Section of Swivel Ball for Air Pipe.

CLEANING GAS CONDUITS.

In cleaning we begin at the producers and work toward the furnaces. To the casual observer it would seem that the operator did nothing more than stick the bent pipe through the opening A and turn on the air. This, however, is, of course, the most insignificant part of the operation. It is necessary that the pipe be given a circular motion, which will bring its discharge end in contact with all parts of the brick lining from one opening to another. A careful, conscientious workman will, in a little time, become very expert in the operation, and when the work is properly done it can be absolutely depended upon to remove all depositions of soot.

In conclusion, it is only necessary to say that th gas is not shut out of the conduit during the operation of cleaning, nor is its flow in any way checked. The producers do not seem to be affected in the slightest degree; in fact cleaning is conducted absolutely without interruption to producers, conduits and furnaces, and that it is efficient is evidenced by the fact that when our conduits have been opened for repairs we have always found them clean to the brick lining.

AUTOMATIC AND CONTINUOUS SAND BLASTING

The following we condense from a recent issue of *The Foundry*.

Fig. 1 shows an automatic, continuous sand blasting arrangement designed for the cleaning of large quantities of small castings. There is a steel plate conveyor which carries the castings beneath the sweeping blast from a series of suspended nozzles which have a rocking motion with suitable arrangements for disposing of the castings and the sand. The apparatus can of course be driven from any available source of power. Also, as the entire apparatus is encased and an exhaust fan provided at the rear, it can be operated without discomfort in the foundry itself.

TRAVERSING THE BLAST.

A primary and important feature is the moving of the blast jets back and forth, a principle adopted in a tumbling barrel designed by Mr. Drucklieb, 42 Reade street, New York, whose ideas are also embodied in the present apparatus. The reciprocating movement of the nozzles secures uniform treatment for all the castings which pass under them.

In the apparatus here spoken of a number of nozzles—dependent upon the width of the machine and the rapidity of treatment desired—are fitted to an iron pipe, which is suspended above the conveyor. These nozzles at their tips are about 6 inches from the surface of the plate; they are inclined slightly toward the rear, as the resulting deflection of the blast by the plate facilitates the cleaning of the under side of the casting as well as the top. This iron pipe is closed at one end and connects at the other with a rubber hose running to the sand blast apparatus. On the closed end the pipe is merely hinged to a support built up from the body of the device, but at the other there is provided a bell crank, to which a reciprocating motion is imparted by a disc crank on a hanger above, or by a motor located on the top of the housing.

THE CONVEYOR.

The castings are shoveled onto the conveyor at the front and travel through the machine at any desired speed, 8 or 10 feet a minute being the usual rate, as this affords ample time for the sweeping motion of the blast to cover every section of the plate. After passing under the blast, the castings fall onto an inclined steel plate, through the perforations in which the sand falls into a lower bin from which it can be taken for later use. An upper sand bin is located just beneath the path of the conveyor plate on its return trip and catches whatever sand does not fall to the lower bin. The castings chute leads either to a suitable box beneath the machine or to a table for inspection.

For the most part it will be found that one trip under the sand blast is sufficient to clean the casting on both sides. Where extremely uniform results are required, however, it is necessary to return some few of the castings to the conveyor for further treatment of the under side. It is the usual practice abroad, where automatic cleaning devices are employed, to return practically all castings for a second treatment, one common arrangement being to place them on a table revolving beneath a blast and station a workman at one side to turn all passing before him that require it and to put on and remove the castings as needed to maintain continuous operation.

The chamber in which the cleaning is done is almost entirely encased, the opening in he front being high enough only to admit the load of castings on the conveyor. The direction of

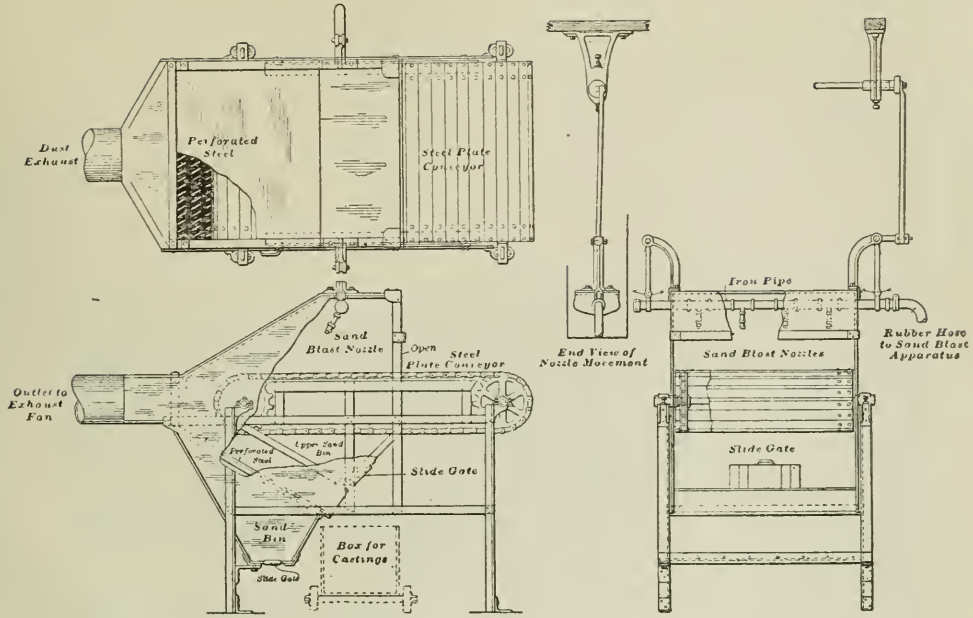


FIG I, PLAN, SECTIONAL AND FRONT VIEWS OF AUTOMATIC SAND BLAST DEVICE.

the blast is toward the rear and this, with the draft of the exhaust fan, carries off the dust and dirt commonly encountered in sand blast practice, rendering the operator free from danger and discomfort.

CLEANING LARGE CASTINGS.

Where a considerable number of large castings of similar type are to be cleaned, an arrangement of sand blast equipment, also designed and built by C. Drucklieb, offers some remarkable advantages in ease and speed of handling and in economy of floor space, all factors of importance in the brisk competition of present day foundry operations. In the installation shown in Figs. 2 and 3, which has been in use for some time with signal success in several forms, heavy car coupler castings are treated.

In the corner of the foundry, not far from the heating furnace, is located a battery of three hooded sand blasts, so arranged that a single trolley line, with proper switching facilities, serves them all without confusion or delay. As they come from the furnace the castings are transferred to the cooling floor, where they remain until they lose their color and are sufficiently cool for sand blast work. One of the castings is then picked up by tongs attached to a trolley and swung around to one of the blasts, entering through an opening in the side and a slit in the roof of the case. The front is open, and through this the operator applies the blast, operating a nozzle by hand. The casting hangs on a swivel and when the front is treated it is swung partly around with a hook and the other sides are

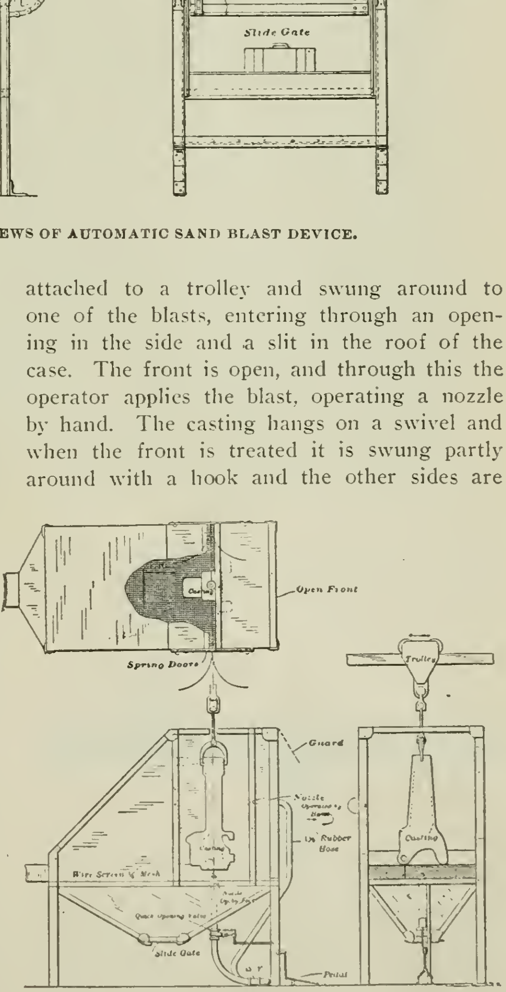


FIG II, SAND BLASTING LARGE CASTINGS.

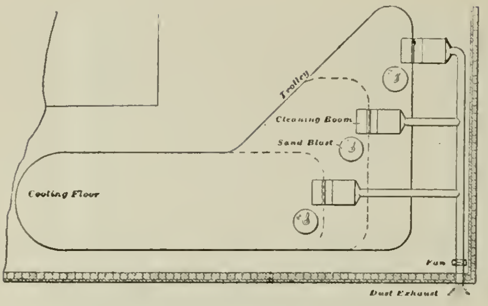


FIG III, THREE SAND BLAST MACHINES.

cleaned. After the outside treatment is completed the hollow center is cleaned by a blast from beneath, the valve of which is operated by a pedal.

Just below the lower level of the casting a wire screen of 1/4 inch mesh is provided to catch the heavier particles blown off, the sand dropping through into a bin equipped with a slide gate. The front of the device is open, except for a small guard for the operator's eyes at the top, but the three hoods connect at the back with an exhaust fan system, and all dust is taken care of in this manner. The process is continuous, the castings swinging through the cleaners and passing to the storage and inspection floor in a complete circuit without any reversal of direction.

THE NIAGARA SAND BLAST

The Niagara sand blast must commend itself first of all by its simplicity. Fig. 1 shows the entire apparatus. It cleans castings fresh from the mold, or just as readily removes scale, rust or paint from metal of any kind and it uses the common shop air pressure of 80 to 90 lbs. The device speaks for itself as to simplicity and as here shown it weighs but 5 lbs.

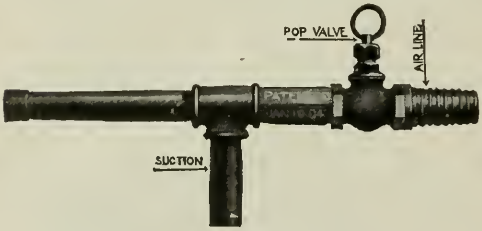


FIG I, NIAGARA SAND BLAST.

No sand tank is required. Sand sifted through a screen having an 1-8 inch mesh is used; the coarser the sand the better. It is siphoned direct from the ground, or from a pit, pail or barrel, and the sand once used needs only to be sifted to be used over and over. The ends are fitted for 1¼ inch hose. The suction should not be over five feet long, and it should be weighted at the end to hold it steadily in position. Should a stoppage occur from any cause the passages are instantly cleared by pressing the nozzle against a firm surface and then turning on the air pressure. The air is thus backed up through the sand hose, removing whatever may be lodged there.

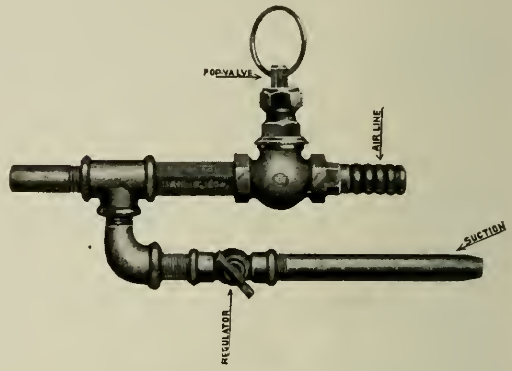


FIG II, NIAGARA PAINTER.

The Niagara Painter, Fig. 2, is the same as the sand blast in its principle of operation. For this a ½-inch suction hose is used and this also should be not over five feet long. Should the pop valve be too loose it should be packed to suit. To back the air into the receptacle holding the paint for the purpose of stirring it up, all that is necessary is to place the hand over the discharge nozzle at the same time opening the pop valve. This operation may also be employed for cleaning the tool if the suction hose is removed from the paint pail. These devices are manufactured by the Niagara Device Company, Buffalo, N. Y.

THE "STEAM" SHOVEL IN ZINC MINING

The Steam Hammer will probably never be known by any other name, although a large and rapidly increasing number of such hammers are now being operated by compressed air. The steam dredge also has its name fixed for life, but we show here a "steam" dredge which is driven by compressed air. The halftone and the description following, by Otto Ruhl, we reproduce from *The Mining World.*

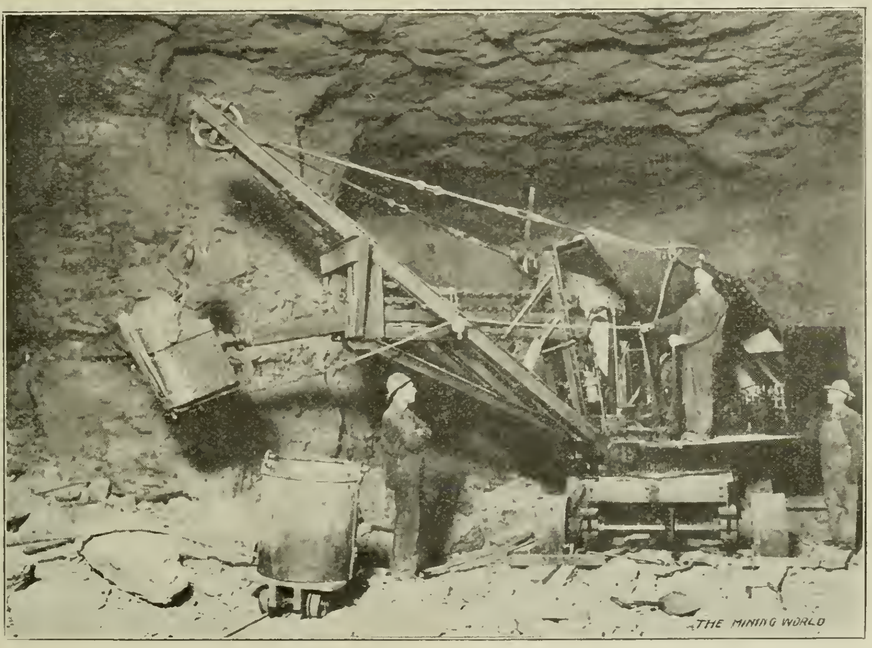
The first steam shovel ever used in zinc mining has been introduced into the Missouri-Kansas district by the American Zinc, Lead and Smelting Co. in its mines at Prosperity. This shovel is being utilized in the No. 2 shaft at a depth of 200 ft. from the surface, in a drift 15 ft. high. The shovel has now been in use about four months and has been tried out very carefully.

The machine was designed by Capt. R. Thew of Loraine, Ohio, who spent some time in the mines of the American Zinc, Lead and Smelting Co. studying the conditions to be met in the construction of the steam shovel. The machine is much like the ordinary steam shovel, the crane being 18 ft. long and constructed of steel.

At the extreme end of the crane the steel cable attached to the shovel for lifting, runs over a pulley down the length of the crane to a revolving drum actuated by an engine which is under the control of the operator. As a part of the crane there is a second arm which works upon a slide bearing and hinges in it at one end. Upon the other end of the arm is fastened the shovel proper. This arm is actuated by a chain belt which will shove it outward into the ore, or pull it backward. The crane is attached to the platform of the machine at its base, and is supported from its outer end by heavy truss rods.

Upon the platform there are three engines, one of which drives the drum which elevates the shovel at the end of the crane, a second which pushes the arm that holds the shovel, while the third engine revolves the platform so that the shovel may be worked in any direction. Each engine is run by compressed air. All the machinery is shut in by thick heavy steel plates which act as an armor, thus protecting the delicate working parts from flying rocks when any blasting is done. The levers for the control of the three engines are at one side of the machine so that one operator may have full control of the shovel. All the machinery is rigidly fixed upon a revolving platform, which is built very strong and heavy, and is supported by heavy trucks to hold the immense load, amounting to several tons. The machine can be moved from drift to drift by its own traction, one engine being used for this purpose. It is not moved on tracks, but heavy boards, which are placed under the wide tired wheels to furnish a smooth surface.

The machine is built entirely of steel, and will wear a long time. The dipper of the


THE MINING WORLD

AIR OPERATED STEAM SHOVEL IN A ZINC MINE.

shovel has a locking bottom, and the operator dumps by pulling a rope. When the shovel is again lowered the bottom is self-adjusting. A set of strong steel teeth are attached to the mouth of the dipper to aid in gathering up boulders. These can be easily replaced at slight expense and prevent the dipper from hard wear.

The machine has not been in operation long enough to fully test its capacity, though it has handled from 200 to 300 cans of material, holding 1,200 to 1,500 lbs. This is equivalent to 250 to 450 cans of the ordinary 1,000-lb. size. Each shovel takes up from 600 to 700 lbs. of ore, and two shovelfuls are required to fill a can. One advantage in this system is that there are no "windies" (cans only partly filled), every can being filled entirely, which adds to the efficiency of operation.

The cost of operating this machine is about equal to 30 hp. for power, or sufficient air to run two machine drills. Two men are required to operate the machine, one to handle the shovel and one to break boulders and get the dirt in position to be taken up. A large amount of dirt can thus be handled, providing too much time is not lost in moving the machine from drift to drift, which is quite an undertaking. If the machine is kept close to a large number of drifts the work will be continuous and can be accomplished at low cost.

The steam shovel cannot be operated in every mine, as certain conditions have to be met. The minimum height of roof is 14 ft., and work in a lower drift would be impossible, unless the machine were remodeled and the present form greatly changed. Thus, only a few sheet-ground mines could operate the shovel, as most of them have roofs from 7 to 9 ft. high. Another limitation is that the machine could not be operated where pillars are placed close together, as a swing of 25 to 35 ft. is necessary. Thus, in soft ground where there are many timbers the shovel could not be used at all.

The highest head power plant in the world has been designed for a Norwegian factory. The total head is 3,287 feet, the water being taken through a seven-mile tunnel from a lake 3,536 feet above sea level to supply six turbines of from 12,200 to 14,600 horsepower each, with direct connected generators.

AIR-DRILLS AND THEIR EFFICIENCY

By Samuel K. Patterson.

Probably no branch of engineering development is on a par to-day with that of air-drill operation from the standpoint of inadequate efficiency. The introduction of the air-drill in mining and as an industrial factor for other purposes was a great step in advance and represented considerable progress in engineering development, but since that time air-drills themselves have made little or no progress in efficiency. Many of the ordinary facts or physical data essential for their operation are practically unknown, and this is due as much to the lack of adequate methods for their determination as to any other reason. Thus, even the question of what is meant by efficiency of an air-drill is debatable ground. The average manufacturer will say that it depends upon the initial air-pressure, air-consumption, and rate of drilling, but that no adequate or scientific conception of the same is possible or at hand. It is a generally accepted theory that air-drills in actual operation work best with an air pressure of 80 to 100 lb. Some extend this to 150 lb. initial pressure. The air-consumption varies with the size of the drill, but for the average drill it is approximately 100 to 150 cu. ft. of free air per minute, compressed to 80 or 100 lb., taking the full supply available from an average 8 by 8-in. compressor. Until recently the speed of such drills, or the number of blows per minute, was variable and practically unknown, and the foot-pounds of the blow has been determined in rare instances only. No indicator diagram of the action in the cylinder has ever been made or is obtainable with the ordinary indicator on account of the inadequacy of this mechanism for such speeds, and because of the high corrective factor due to inertia and to the velocity of its parts. The action of the valves, and the effect of the port in reducing the air-pressure, are largely a matter of conjecture.

All drills for mining purposes can be divided essentially into two classes, those in which the valves operate by mechanical means imparted by the motion of the piston itself, and those operated by a differential air-pressure produced in various ways. The position of the valve is apparently determined largely by question of convenience in design from an operative and constructive viewpoint, rather than from the view of efficiency or air-consumption. The Ingersoll-Rand pneumatic hammers and drills have a valve operating by differential air-pressure at right angles to the motion of the piston, and installed in the handle of the device or at one end of the piston-cylinder. This necessitates comparatively long ports for the action of the hammer or drill during a portion of its stroke. The Rex pneumatic air-drill possesses a mechanically operated valve installed in a cylinder parallel to that of the piston proper, and possesses much wider ports and equally distributed passages. The McKiernan drill possesses features of both types, with a side valve-chamber operated by differential air-pressure. Other types are more or less similar, and the data herein given refer more especially to the average drill used in mining. Air-driven hammers, saws, augers, riveting machines, and a number of other devices, fall equally in this category, but their range is so wide, and their variability so great, that they have not been considered. However, all the conditions which hold in this particular type hold equally well in regard to the majority of air-driven tools where the frequency of the device operated is of such a character as to preclude the utilization of the ordinary appliances in their measurement.

The ordinary steam indicators as used in the indication of steam units, pumping machinery, ammonia and air-compressors, are inadequate as instruments of precision in this particular field. In fact, no satisfactory indicator for high-speed gas-engines is as yet available. Equal conditions hold in regard to high speed steam engines, especially those direct-connected to electric generating units, and the necessity for a satisfactory indicating device where the problems of inertia and rigidity have been satisfactorily met for these speeds will undoubtedly prove as great a boon in the utilization of compressed-air as in the production of power by any kind of the high-speed engines. In regard to the action of compressed air in an air-drill it is assumed to be somewhat similar to that of steam in reciprocating-pump machinery. No cut-off exists in either type, and the pressure is supposed to be maintained more or less constant throughout the stroke. However, the use of indicators or pressure-gauges direct-connected to the cylinder of air-drills registers a fall in pressure of from 20 to 40 per cent. over that existing in the hose and valve-chamber, and whether this is due to inadequate size of ports or is in reality a measure of the average or mean effective-pressure is unknown. Only recently has this drop in pressure in the air-cylinder of the drill become generally known, and a more thorough study of the phenomenon is being undertaken.

Again it has been the generally accepted dictum among air-drill operators and superintendents that air-drills operate at a maximum efficiency of from 80 to 150 lb. air-pressure. That such drills should operate more efficiently at higher pressures is a reasonable conclusion if faults of design do not enter. It is also reasonable to assume, within certain limits, that a given drill should possess a maximum efficiency at a given initial air-pressure, due equally to details of design and operation. However, the statement that all air-drills are limited in their maximum efficiency, independent of design, to certain values in initial air-pressure is, if correct, undoubtedly due to faults in the design and operation of such types. The use of differential air-pressure in the operation of the valve, with this differential air-pressure obtained by allowing the direct ejection of a portion of the air into the atmosphere through an intermediate air-chamber at one end of the valve-piston, is not only an extremely wasteful device for the operation of the piston, but is an unnecessary one as well. It has also been the generally accepted conception of engineers that all drills other than compressed-air drills have been tried and proved unsatisfactory. While undoubtedly this may be true under present conditions, that it is a necessary condition is by no means a foregone conclusion.

The type of drill in which the air is compressed by electrical means in the immediate vicinity of the drill cylinder, to be used at once, represents a possible development along lines possessing considerable advantages.

[This allusion to the Electric Air Drill is misleading. It is in a class by itself and not comparable as to mode of operation with drills as ordinarily driven by compressed air. Its constituent compressor, so called, is more correctly a pulsator, and its reduction of pressure upon one stroke is a function as essential as its compression upon the other stroke. Ed. C. A.]

The condition of affairs may be summed up in the statement that our knowledge of operating conditions in the utilization of compressed air in the average air drill, and in other air drills, is essentially inadequate, and more complete information is highly desirable.

* * * * * * * * *

COMMERCIAL EFFICIENCY.

Mechanical efficiency, however, is in reality a matter of minor significance in the operation of air drills in comparison with that involved in a consideration of the factors affecting the commercial efficiency. Thus, the labor cost and other items are such in the operation of air drills that the efficiency of a drill is measured in reality by the time of boring, and is practically independent of air consumption in the choice of a type. The drill which has a small percentage increase in the rate of digging can in reality consume several times the quantity of air in its operation and still be more efficient, on the commercial side, than the more efficient mechanical type in the actual operation of the drill itself.—*Mining and Scientific Press*, San Francisco.

THAWING EXPLOSIVES

The following is noted from a paper by Mr. P. N. Denison, read at the Toledo convention of the Ohio State Stone Club:

During the year ending June 30, 1906, we find the item "thawing dynamite" second in the list of accidents occurring in the use of explosives. Sixty-six accidents due to thawing, with thirty-two fatalities, and I venture to say nine-tenths of them could have been prevented had proper care been exercised in the thawing.

The following table from the British Government report covers all accidents from thawing from the year 1872 to December 31, 1905. Every method mentioned is contrary to law in England:

1 Heating over fire	38
2 Reheating water in which dynamite had been previously placed to thaw	11
3 Placing the explosives in water, then heating that over a fire	10
4 Placing the dynamite cartridges in ovens	8
5 Thawing cartridges in the hands over a lighted lamp or candle	7
6 Placing dynamite in hot ashes	7
7 Warming on a shovel over a fire	5
8 Placing cartridges on top of heated stone	5
9 On a hot iron	4
10 On a steam pipe	2
11 Rubbing cartridges together to warm them by friction	1

Our record shows nearly as many accidents in twelve months as England had in thirty-four years.

Frozen dynamite is a dangerous article to handle. The nitro-glycerin is crystallized. Opening the end of a cartridge, you see the bright little specks that look like mica, and these crystals are sensitive to friction.

In the United States from July 1, 1905, to June 30, 1906, five accidents were reported from "breaking cartridges in two." A man was killed at Bellevue, Del., by breaking a frozen cartridge of 60 per cent. N. G. powder in his hands. This practice is prohibited by law in Austria.

A blaster in this State was killed by tamping improperly thawed gelatin dynamite with a wooden bar. He was tamping the first couple of sticks when it exploded and blew the tamping bar through his body.

At Mitchell, Ind., last winter a man was killed when attempting to open a box of frozen dynamite with an ax or pick. Ordinarily, however, frozen dynamite is hard to detonate; in no case do you get its full strength, and when but chilled a great per cent. of its strength is lost. Therefore it is necessary to thaw this explosive, and now we come to the actual work in preparing for a shot in cold weather.

Don't thaw the cartridge in hot water. I find this a common but very poor practice. It injures the explosive power by killing the effect which should be had from the soda ingredient, the paraffine coating is washed away, and, N. G. being heavier than water, there is always the chances for a remaining puddle of "soup," as the safe experts call it, to cause an accident. Also the water-soaked cartridges present an easier target for Jack Frost than those thawed in a dry atmosphere.

To thaw by throwing live steam against dynamite presents nearly the same problem as that of hot water.

Don't thaw over live steam pipes, on hot iron, around an open fire or on the boiler. The last named "don't" claimed a victim last winter at a Kalida, Ohio, quarry. Dynamite thawing on top of the boiler exploded and killed the engineer.

For thawing large quantities of dynamite, a thaw-house heated by hot water pipes, the radiators being at the back or sides of the building and protected by a wooden partition, is by far the safest method. If it is arranged that the cartridges may be laid out on grooved shelves, each stick by itself, so much the better, for each will then obtain a uniform and regular heat and insure best results.

For small quantities there are several safe methods of thawing, just as easy and no more expensive than some of the dangerous methods now in vogue, and I cannot see why they are not generally used.

For instance, a man will take a bucket, fill it with dynamite cartridges and pour hot water over them. When they are good and slushy he takes this mush out, pours it in the drill-holes, gets a bad shot, and either jumps all over the dynamite, or explains it by saying his stone is changing and the bottom is harder to shoot. Why can't he take the bucket filled with dynamite, then loosen up and buy a larger bucket to hold the water? Place the smaller bucket within the larger and cover with rags or anything to hold the heat. There you have a perfectly safe thawer, your dynamite is in the best of shape, and you save much of its explosive force. It can be carried to the shot and loaded direct, thereby minimizing the chances of being chilled.

There are thaw-kettles on the market, built on much the same plan, which can be purchased from any explosive manufacturer.

For somewhat larger quantities, use a barrel for the hot water and a milk can for the dynamite.

Manure makes a good thawer where the quarry is so situated that a supply can be kept up. The thawing-house should be covered to a depth of two feet which will generate a good heat. Authorities differ on the length of time manure will hold its heat-giving qualities. Some say two or three weeks, while others claim the same manure covering will give out heat all winter long. The contractors on the New York subway work used this method generally, burying a box sufficient to hold three or four cases of dynamite, in manure, then dug it out when needed. Opinion there seemed to give manure a life of two or three weeks only.

If thawing-kettles are used it is best to carry them direct to the shot. In large quantities where you have a stationary thawing-house, protect the dynamite on the way to the shot by, say, a burlap covering, or provide a box wherein it may be placed and covered up when hauled to the blast. In other words, once thawed, keep your dynamite from all possible chance of exposure and get your shot off as quickly as loaded.

The most practical explosive for use in this particular territory, principally of limestone quarries, is the low-freezing grades of dynamite. This calls for no special detonators or extra trouble, and is, without doubt, one of the best things on the explosive market today. In strength it corresponds to the well-known grades of Hercules dynamite.

It will not freeze until the thermometer reaches 30 degrees Fahrenheit, two degrees below water-freezing point. That is the resistance to cold weather claimed at present; it will not freeze above 30 degrees Fahrenheit, but I have records where this powder was used in weather much below 30 degrees, and it was not frozen.

MOTOR-DRIVEN COMPRESSORS FOR ROCK DRILLS

A visit to towns in the Lake Superior region recently, where rock drills are in abundance not only for quarrying, but for grading of streets, etc., showed that motor-driven air compressors for supplying these pneumatic rock drills are displacing steam plants. Electricity can usually be supplied by central stations for this purpose at a rate which will make it uneconomical to operate a steam plant. In the cases where the steam direct from the boiler is supplied to operate the rock drills, the trouble from freezing in the winter and the trouble with steam hose make the motor-driven compressor desirable. Mr. William Chandler, in a discussion at the Michigan Electric Association in August, spoke of a 225-h.p. motor driving a compressor supplying rock drills at Sault Ste. Marie. This compressor plant made a saving of $7,000 in first cost over that of the former steam plant, which would otherwise have been erected by the contractor.—*Electrical World.*

SENTIMENTAL SCIENCE

The following neat presentation of the essentials of the Goldschmidt Thermit process is translated from the German of Haus Dominik and appears in the latest issue of *Reactions.*

Once upon a time there lived an Aluminum scraplet—a neat and pretty grain of metal. It had a deep and almost invincible passion for an oxygen atom. In the realm of nature there are not so many conventions to be observed as among mankind and thus it came about that soon after the creation of the world our Aluminumlet could seek out its love and enter into intimate and permanent union with oxygen. Like many other happy marriages, however, the glamour of pre-wedding days did not continue right along, as the union resolved itself into common gray clay.

For thousands of years the clay marriage led an uneventful existence, until man interfered in their relations. Then, of course, there was an end to peace and quiet. What time, cold and heat had failed to do, was achieved by the electric current. It tore asunder the closely united. Bright Aluminum remained in the electric furnace, dissolved in incandescent separation pains, while the divorced oxygen escaped into the open.

Now, we cannot conceal, much as we regret it, that oxygen's conduct was not free from reproach. While Aluminum, even after the separation, continued faithful, oxygen went in search of other attractions. Its liking for the sparkling and glistening was undeniable and whenever it saw something bright, it wanted to go and make up to it. As Aluminum had been torn away, it sought and found consolation and distraction with iron. The two formed a new union, which was registered in the chemical register as Peroxide of Iron. In daily life it was called Rust for short.

You must not blame Oxygen too much for its faithlessness—it cannot help its extraordinarily versatile and fiery temperament. Besides, even in its new union, it by no means felt entirely happy. Although its connection with iron gave it temporarily a prominent position in the world, in its heart the old liking for Aluminum still lived with unabated vigor, the force of which electrochemists give as 3455 Thermal units per kilogram. The Rust menage continued not exactly unhappily, but still not happy, while bright Aluminum sorrowed in loneliness.

That state of affairs awakened the compassion of Dr. H. Goldschmidt, of Essen, and he resolved to end this misery. In order first of all to offer an opportunity of mutual approach to the separated ones, he mixed together the Aluminum particle and the iron rust. That did not help much at first. He knew the right spark to rekindle the affinity of the oxygen for Aluminum, however. Then happened what in old tragedies is called the reward of love and faithfulness, while Chemistry dubs it a thermochemical reaction. The union Rust broke up. With a sudden rush, oxygen tore away from iron and fell into Aluminum's arms, reuniting once more into the old clay. So strong was the impact and so tremendous the exuberance of feelings, that in a moment the whole concern scintilated in a refulgent glow. In the vessel where these things happened, there lay at the bottom superheated liquid iron and at the top liquid clay at a temperature of 5400°F.

BAROMETRIC CONDITIONS AND THE FREEZING OF WELLS

It is a rather curious fact that shallow, open wells give less trouble from freezing up in winter than the deeper drilled or double tubed driven wells, where the inner or pump tube is carried below the outer casing. The following notes by the United States Geological Survey throw light on the matter:

The freezing of wells is practically confined to districts where the air temperatures frequently go considerably below zero, and where the materials penetrated are either porous or contain actual openings and passages through which the air can circulate. A study of the phenomena as a whole shows that they are closely connected with barometric changes. The direct cause of the freezing seems to be an indrift of cold air at periods of high barometer. Change of weather, reversing the direction of the air current, produces thaw. In open wells, where air obtains access through the soil and at the junction of curb and cover, a cement cover should be tightly fitted to the curb, and the curb itself should be coated with cement for some distance below the surface. In drilled or double-tubed driven wells the current of cold air drawn in at periods of high barometer between the outer and inner casing near the surface and passing out in a porous bed at the bottom above the water level will cause freezing if the water is pumped so that it stands in the inner tube above the lower end of the outer casing; and a long-continued current of such cold air may cause freezing of the ground water about and in the well tube. For this condition it is suggested that the space between the outer and inner tube near the surface be packed with some impervious material. A filling of cement resting on an improvised plug is probably the most effective. The home-made rag packing sometimes used is too porous to serve the purpose. The same treatment is suggested for wells with leaky casings, for driven wells passing through rocks porous enough to permit the passage of large currents of chilled air during periods of high barometer, and for wells in which the outer casing ends in some cavern or open passage; that is, the space between the well tube and the pump tube near the surface should be tightly plugged with impervious material.

AIR LIQUEFYING TESTS

The accompanying table, from Bulletin 21 of the University of Illinois, gives the results of recent tests in connection with an air liquefying plant at that institution. The tests were made in the mechanical engineering laboratory to determine (*a*) the most economical conditions for operating the liquid air plant belonging to the department; (*b*) the power consumed and cost of production of liquid air in plants of this type; (*c*) the efficiencies of the separate units composing the plant, and (*d*) the keeping qualities of liquid air in the Dewar bulbs of different sizes, mirrored and unmirrored, enclosed in felt receptacles and open without covering of any kind.

A description of the four-stage high pressure air compressor and of the liquefier, which is of the Hampson laboratory type, is given with details of the methods of measurements, etc. In regard to the temperature of the air entering the liquefier, it is remarked: "We have measured the influence of temperature over a range between 0 degree and 20 degrees C. for two pressures, namely 2,000 and 3,000 pounds per square inch, and the data are given under tests 1 to 7 inclusive. If the inlet temperature were below zero the efficiency would be correspondingly greater and the cost of production less; but it does not seem advisable in intermittent operation of the plant to reduce the temperature of the entering air below zero, as the trouble and labor necessary to keep a freezing mixture of salt and ice in the precooler more than balance the gain in efficiency."

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
No	Receiver Pressure lb. per sq. in.	Ten. Entering °C.	Temp Air Leaving Liq °C.	Room Temp °C.	Motor Speed r. p. m.	Compressor Speed r. p. m.	Grams of Air Liquefied per hr.	Total Wt. of Air Delivered per hr. grams	Percent of Air Liquefied	Delivered horse power	Grams per d. h. p. hour	Pints Liquefied per hour	Cost of Power per Pint dollars	Total Cost per Pint dollars	Per cent d. h. p. Available in Liquid Air
1	2000	11	9	18	938	178	1555	33700	4.8	15.40	101.0	3.53	0.288	0.39	1.5
2	2000	19	17	16	918	173	1362	32800	4.2	15.20	99.6	3.09	0.324	0.44	1.3
3	3048	20	18	24	1130	210	2980	39600	7.6	19.74	151.0	6.77	0.192	0.24	2.3
4	3110	10	9	18	1139	211	3165	39800	8.0	19.50	162.0	7.18	0.178	0.23	2.4
5	3140	4	4	19	1129	209	3170	39400	8.0	20.0	158.5	7.20	0.183	0.23	2.4
6	3137	0	5	19	1131	210	3262	39600	8.3	20.2	164.0	7.46	0.178	0.22	2.5
7	2128	0	4	21	1137	210	2495	39800	6.3	18.2	137.0	5.67	0.213	0.27	2.1
8	1116	-2.5	4	21	1155	214	560	40200	1.3	13.8	39.8	1.25	0.728	1.01	0.8

TABLE OF AIR LIQUEFYING TESTS.

The loss of energy in producing liquid air is shown in column 16 of the table. Under the most favorable conditions, it is added, the available energy of the liquid air is only two and one-half per cent. of that expended in producing liquefaction.

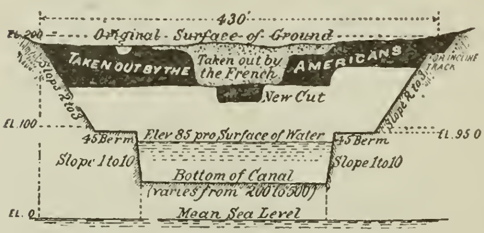
The cost of production is given in columns 14 and 15 in the table. The only expenses included, it is stated, are cost of power used, estimated at eight cents per kilowatt hour, and cost of one attendant at thirty-five cents per hour. When running at 3,000 pounds pressure the cost of the liquid air obtained is given as twenty-two cents per pint. When running at 2,500 pounds pressure with air entering liquefier at 15° C. the cost was thirty two cents per pint.

In a recent description of a commercial liquid air plant at Norwich, Conn., [COMPRESSED AIR MAGAZINE, March, 1908.] it was stated by the engineer that the "liquid air drawn from the system is about seven and a half pounds per h. p. h. of energy expended." The best record at the university test as shown in the table was 164 grams, less than two ounces, per h. p. h. At the liquid air plant at Los Angeles, Cal., the cost of production of liquid air is given as about ten cents per gallon.

ALL ABOUT THE PANAMA CANAL

The following from the *Sphere*, London, is, with its accompanying cut, a marvel of conciseness and clearness:

Since May 4, 1904, the Americans having bought for a sum of about £8,000,000 all the rights and property in the derelict French company, have been in possession of the works and have continued operations on a truly gigantic scale in face of the innumerable difficulties which beset all works in a tropical climate. The chief difficulties which the new proprietors have had to encounter may be divided broadly into three sections: (1) The problem of health and hygiene; (2) the obtaining and maintenance of a sufficient force of laborers; (3) the engineering problems connected with the undertaking. The control of the river Chagres, with its sudden and enormous floods, has been one of the cheap difficulties to be contended with, and large controlling works and diversions will have to be made to enable the dam to be built. Double sets of three locks in flight capable of accommodating vessels of 1,000 ft. in length and 100 ft. in width will carry the vessels from sea-level up to the great Gatun Lake, which will have an area exceeding 170 square miles. The navigation channel through this lake will have a minimum depth of 45 ft. and a width at bottom of from 1,000 ft. at Gatun down to 200 ft. through the Culebra cutting, the narrowest part of the canal. At Pedro Miguel, a distance of about 10 miles from the Pacific entrance, the summit level will end, and a descent of 30 ft. will be made by means of a lock to a channel of some 500 ft. in width, extending as far as Miraflores. Here two more locks will lower vessels to the Pacific sea-level. From Miraflores a width of 500 ft. is maintained until the Pacific entrance is reached.



SECTION OF CULEBRA CUT.

WELDING LOCOMOTIVE FRAMES*

By A. W. McCaslin.

On the Pittsburgh & Lake Erie Railroad we repair some of the engine frames, as many others do, without removing them from the engine and, as far as superficial examination of the completed job would indicate, we have very good results. I do not say that we weld these frames, for, like Mr. Uren, I do not consider that such an operation, made without a lap of some kind, deserves the name weld. In fact, this butting of frames is simply a burlesque on proper welding. I have satisfied myself as to the virtue of this so-called weld by making several in the shop, granting them many advantages that cannot be offered on an engine, and have found that they would invariably separate, showing very little resistance to a light crosswise blow under a small steam hammer. The breaks show that a union of the metal had been effected, but also show a very feeble tenacity; yet, knowing these facts, we are very much in favor of repairing frames this way, wherever it is possible to spread the frame and take the heat, as it frequently keeps the engine in service until the times comes for general repairs, and this means quite a saving.

We have what we think are splendid burners, and build a very satisfactory furnace with standard size fire brick. Mr. Shoenberger, foreman blacksmith in the Ft. Wayne shop at Pittsburg, kindly furnished me the original design for both of them. They are illustrated in the sketch. I build the furnace with the bottom inclined as shown on blue print, making it about 1 in. lower at its center than at the fuel holes at the ends. Have also added a small slag hole at the center near the bottom, so the slag will not gather and be blown up against the frame. We use two burners, and crude and carbon oil as fuel, and take a very slow heat. The bottom, inclined as mentioned, helps to prevent the wasting of the bottom side of the frame and gives the heat a start to return over the top of the frame and out the peep hole. When the heat is complete the furnace is pushed into the pit and the work completed with light sledges.

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*From a paper before the International Railroad Master Blacksmith's Association.

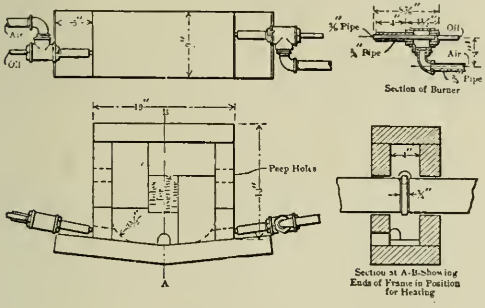

Air
Oil
5"
19"
B
A
Peep Holes
Holes for Inserting Frame
⅜" Pipe
⅜" Pipe
5⅜"
Oil
Air
¾ Pipe
Section of Burner
¾"
Section at A-B Showing Ends of Frame in Position for Heating

FIG I, FURNACE AND BURNER FOR WELDING LOCOMOTIVE FRAMES.

I do not approve of making the side V weld under a heavy steam hammer without using a channel tool. The work will be satisfactorily performed, however, if done under a small steam hammer with light blows, or with heavy sledges. In this case the laid in piece should not be made with the overhang cut too close to the frame. Side heats should be drawn well up to the point of the V piece, and this stock driven back into the weld, at the same time a lap being formed where it is much needed, that is, at the ends of weld on the top and bottom of the frame.

If the side V weld is made in a frame under a heavy steam hammer there should be a heavy channed tool placed on top. This tool should be 8 in. wide, 2½ in. deep, and ½ in. longer in the crown, and ¾ in. longer at the mouth than the cross section of the frame, that it may release readily. It will shear off the extra stock, prevent the laid in piece from lengthening endwise, and will drive it back into the weld, thus forcing it against the walls of the V, and lengthen the lap lengthwise the frame. A second heat should be taken on the laps, in order that there may be no hole or opening at the points of the weld. This is not only the most convenient weld to make in repairing frames, but it is the best.

We sometimes make, in front sections of frames and in large hammer piston rods, what we call a lap and V weld; we flatten the end of each piece nearly one-third, make the lap and weld as shown on the sketch, then drive back the end of the laps and lay in a V; this insures a solid center and a solid side opposite each V. It also throws the laid in pieces about 6 in. apart. This weld will elongate evenly when being reduced, and will not slip or shear as the ordinary lap or V weld will. The drawing clearly shows how this type of weld is made.

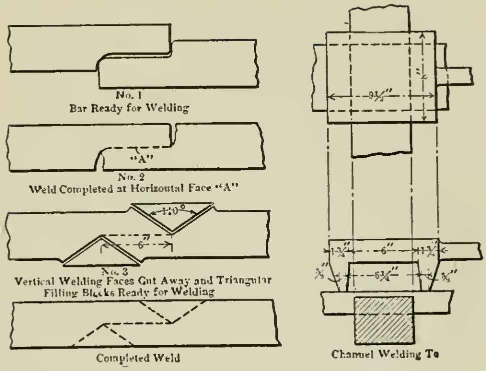
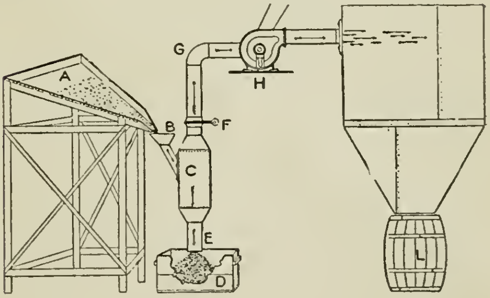

No. 1
Bar Ready for Welding
"A"
No. 2
Weld Completed at Horizontal Face "A"
110°
6"
No. 3
Vertical Welding Faces Cut Away and Triangular Filling Blocks Ready for Welding
Completed Weld
9½"
8"
1¾"
6"
1¾"
⅜"
6¼"
⅜"
Channel Welding To

FIG II, LAP AND V WELDS AND CHANNEL TOOL FOR HEAVY HAMMER WORK.

SEPARATING SAWDUST OR LEATHER FROM SMALL TUMBLED ARTICLES

Tumbling removes sharp edges and scratches from small metal goods. The first tumbling is with sand or gravel, or sometimes steel slugs are used. The articles are then tumbled with leather or saw dust to give the first finish and then they must be separated and cleaned. The sketch here given of apparatus for the purpose comes from The Brass World.



SEPARATING TUMBLED WORK.

There is a trough of wood *A*, lined with sheet zinc and inclined toward the funnel *B*. This trough is to receive the articles as they come from the tumbler and is inclined so that they may be readily pushed into the funnel by hand. The funnel B is rigidly attached to a pipe, C, which tapers down at E. Both the funnel, B, and the pipes, C and E, are made of tin or galvanized iron. The pipe C is about 8 in. in diameter, and E is about 6 in. On the top of C the pipe is again tapered to 6 in. and a slide blast gate, F, is placed to control the blast. At G the pipe turns and is connected with an exhaust fan, H. The other end of the fan or the exhaust side is connected with a large sheet iron collector of the usual type. This is the well-known appliance used for collecting buffings, sawdust, etc., when an exhaust fan is used.

A box or other receptacle, D, is used to catch the cleaned articles. A barrel, L, receives the sawdust or leather. To clean a mixture of small articles and sawdust, it is first dumped into the trough A. This is not so inclined that the articles will slide into the funnel alone, but they must be pushed with the hands. As they pass through the funnel B and fall down through the pipe C, the air that is sucked up by the fan removes the sawdust, which is carried over into the collector, and the articles cleaned fall into the box D.

PNEUMATIC SULPHUR MINING

The French process of obtaining sulphur is a highly interesting development of practical science. The latest improved and most successful method is briefly described as follows in Mining Science:

A well is driven through the various strata to the sulphur-impregnated beds in much the same manner as is usual in sinking wells for oil and gas. In each well there are placed concentrically four lines of pipe having diameters ranging from 10 in. to 1 in. Superheated water and hot air is forced down the pipes and the spaces between them to melt the sulphur and to bring it to the surface. The hot water flows down between the two outer pipes, which are respectively 10 in. and 6 in. in diameter, and passes into the limestone, melting the sulphur. The quantity of sulphur melted and the range of action of the water depend on the temperature of the water and on the pressure at which it is supplied. The heavy, melted sulphur runs back into the sump around the well pipe, which it enters through holes provided for this purpose. Hot, compressed air is forced down through the smallest or 1-in. pipe and at the bottom of the well mixes with the melted sulphur and forms an aerated mass sufficiently low in specific gravity to allow the water pressure to elevate the melted sulphur to the surface, where it is discharged into large rectangular vats constructed of rough planking. The dimensions of the vats vary somewhat, but they are made as large as 350 ft. by 250 ft. by 40 ft., and some of them are so arranged that railroad trains can pass between them. The vats are filled as an ordinary water tank would be, but the viscosity of the sulphur as it cools prevents the formation of perfectly horizontal layers, and the flow of sulphur is being constantly deflected to different parts of the vat. In this manner cooling, solidification and feeding go on simultaneously. The hardened sulphur is broken up by workmen either by pick, crowbar and shovel, or by blasting.

A CUT-OFF AND WHAT IT CUTS OFF

Railroad lines as first laid out are often far from the best that might be, on account of the limitations of practical economy. As earnings accumulate improvements may be made giving increased advantage to the system. One of these costly, but ultimately cheap, corrections of original plans is the 28 mile cut-off on the main line of theLackawanna Railroad, which has been lately put under contract, and will effect a great reduction in curvatures and grades, besides actually shortening the line 11 miles. The present line has a maximum grade of 60 ft. to the mile, while that of the cut-off will not exceed 29 ft., and the total saving in curvature will amount to 1,560 degrees. There will be no grade crossings and no tunnels on the cut-off, so that altogether the advantages secured are numerous and important.

The principal feature of the cut-off will be an embankment 2½ miles long with an average height of 90 ft. This, said to be the largest railway embankment ever made, will contain 6,625,000 cu. yds. of material. There will also be a cut requiring the excavation of 541,000 cu. yds. of solid rock. This cut will be ½ mile long and will attain a depth of 132 ft. There will be required in all 13,000,000 cu. yds. of embankment and 13,154,500 cu. yds. of excavation, of which 4,293,500 cu. yds. will be rock.

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NOT A HOUSE ORGAN

The following from *Engineering News*, explains itself:

Sir: We regret to note, in your issue of Sept. 17, a reference to "Compressed Air Magazine" as the "house organ" of the Ingersoll-Sergeant Drill Co.—more correctly the Ingersoll-Rand Co. This is an error which we believe you will be glad to correct.

"Compressed Air Magazine" is not, and has never been, the "house organ" of any manufacturing concern. Established in 1896, it has since that time been published as an independent trade journal, owned and edited by the President of the Ingersoll-Rand Co.

It is not issued to exploit any machine of any manufacturer. Its aim is the development of a vast field of engineering industry. It is the exponent of a distinct branch of engineering science and is the only publication in the world exclusively devoted to the subject of compressed air in all its applications. Its list of paid subscribers covers every state and territory in the Union and more than thirty foreign countries. Its policy is that of the broad-gage technical journal, not for a moment that of the subsidized "house organ."

Trusting that you will set this matter right before your readers, we are,

Very truly yours,
"Compressed Air Magazine,"
Lucius I. Wightman,
Treasurer and Business Manager.
11 Broadway, New York City, Sept. 18, 1908.

BOOSTING THE LITTLE COMPRESSORS

The ultimate power economy of the Electric Air Drill, in the operating of which, as our readers will remember, the electric current is transmitted to the *pulsator*—not compressor—close to each individual drill, has led to some promulgation of the proposition that it would be generally profitable where drills or other air operated tools are installed in mines or elsewhere to use small electric driven compressors close to the work instead of installing large compressors in the power-house, with suitable pipe lines. In advocating this idea Fearnside Irvine, before the Institute of Mining and Metallurgy, says some rather astonishing things. For instance:

"Small compressors, with small cylinders, whose cubical contents bear a very much smaller relation to the cooling surfaces of the cylinder walls and ends than is possible in larger sizes, are, especially when single-acting, very efficiently cooled; their piston speed in compression is also very low. Take, for instance, a single-acting cylinder with 9 in. stroke and 10 in. diameter, 300 r. p. m., cooled in jacket and head, the cooling surface would be 361 sq. in., the cubical content 706=1 sq. in. to 2 cubic content. In a cylinder 48 in. stroke by 22 in. diameter the contents are 23,000, the cooling surface 3312=1/7.

"Again, the speed of compression at 75 r. p. m. for the larger compressor=600 ft. per min., and for the smaller compressor 225 ft. per min.; thus, the time in contact in the smaller cylinder=2.6 times that of the larger cylinder, and the surface, 3½ times as large,=9¼ times more cooling effect. So far as efficiency is concerned there is little difference between the two, and the small compressor working underground is a distinct advance upon the working of the large one on the surface.".

It is necessary first to correct some of these figures. The content of the larger cylinders, one stroke, is: $22^2 \times .7854 \times 48 = 18{,}246$ cu. in., instead of 23,000, and the cooling surface—the interior surface of cylinder and head—is, for the cylinder: $22 \times 3.1416 \times 48 = 3317$ sq. in., and for the head $22^2 \times .7854 = 380$ and $3317 + 380 = 3697$, instead of 3312.

The actual ratio of "cooling surface" is, for the smaller cylinder: 361÷706=.511 and for the larger cylinder: 3697÷18,246=.202, or 1/5 instead of 1/7. The ratio of cooling surface of the smaller cylinder to that of the larger cylinder, then, is: .511÷.202=2.53, or 2½ times instead of 3½ times.

The assumptions and deductions as to the time of contact of the air in the two cylinders are entirely wrong. With the small compressor running at 300 r. p. m., the time for the half stroke would be 1/600 min., and the time for the half stroke of the larger compressor would be 1/150 min., or four times as long; then, with the larger compressor having four times the advantage as to time, and the smaller compressor having 2.53 times the advantage as to cooling surface we have 4÷2.53=1.58, which shows the preponderance in favor of the larger compressor.

Now, we did not originate and are not responsible for this line of investigation. We are inclined to regard it as an absurdity all through. As a matter of fact, the possibility of cooling the air during the compression stroke can only occur during the latter part of the stroke. During the entire intake stroke and for a portion of the compression stroke the air must necessarily be heated rather than cooled, as the cylinder surfaces must be somewhat warmer than the incoming free air, and it is no wonder that experience actually shows very little cooling of the air during compression as the effect of water jacketing, and that each compression must be regarded as practically adiabatic. This is not saying that water jacketing is not necessary, as it certainly is so as a means of keeping the surfaces cool enough to permit proper lubrication.

The above illustrates the fallacious lines of "argument," which are being promulgated for the multiplying and localizing of small compressors in mines, and elsewhere as preferable to large centralized and concentrated plants. It is mostly talk, after all, as the practice is not being adopted, and is not likely to be where there exists sufficient experience to dictate.

COSTS AND OTHER CONDITIONS OF ELECTRIC AND COMPRESSED AIR TRANSMISSION

The following letter, which speaks for itself, we reprint verbatim from a recent issue of *Mining and Scientific Press*, San Francisco.

Sir—Referring to an article entitled "Underground Air-Compressors," in your issue of August 1, I wish to point out what I consider to be some misleading statements. To quote from the article: "The underground compressors, taking electric power at practically the same potential as a compressor at the surface, had the advantage of saving, first of all, the capital-cost of the pipe-lines, and was thus able to generate compressed-air at a lower pressure . . . (because of the loss of pressure due to transmission in the pipe-lines). This statement would lead one to suppose that an electric transmission-line costs practically nothing compared to the cost of one for transmitting the same power in the form of compressed air. This is not by any means the first time I have seen this asserted, and never have I seen it contradicted.

As a matter of fact, judging from my own experience, the electric transmission-line will cost more, in most mines, than that for transmitting air. This may not be the case on the surface, where electricity can be transmitted at a high potential over small bare wires carried on poles, while the air-pipe lines have to be buried, but underground-conditions in most mines are quite different. If an electric transmission line is expected to be permanent in a wet mine, especially when there is acid in the water, all conductors must be in the form of lead-covered cables, and these cables must be further protected from mechanical injury by either steel or wooden armor. This I have learned by sad experience to be true, even when the current is carried at a low voltage. Underground rubber-covered wires carried on glass insulators will, after a while, leak as much power as a very poorly constructed air-line, and the wires will break wherever they come under a drip. At the mine with which I am at present connected there is an installation of electric and air-driven pumps, side by side, of about the same capacity, affording an excellent opportunity for comparison in the costs of their respective transmission-lines, 1600 ft. down a vertical shaft. The cost of the cable to supply the current to the electric pumps was some three hundred dollars more than the cost of the pipe supplying air to the compressed-air pumps. It has been stated that the cost of putting in air-pipe is greater than that of electric wiring. This also is sometimes not true, depending very much on circumstances. In the installation to which I have just referred, putting in the electric cable probably cost the most, but an exact account was not kept. An expert had to be obtained from San Francisco to do the splicing. As this could not be done either vertically or in a wet place, the cable had to be spliced before lowering down the shaft. As it was not strong enough to support its own weight, it was necessary to lash it at intervals to a wire cable as it was lowered, and afterward to cut it loose from the cable and clamp it to the shaft timbers. Unforeseen difficulties, such as the two cables becoming twisted around each other, and the fact that the hoisting engine was not strong enough to support the total weight, made the operation anything but as simple as it would seem. Now that they are both in place, if anything happens to the air-line, any miner can replace a length of pipe, but if something should get loose on a cage and rip out a piece of the cable, the consequences might be disastrous and expensive, carrying, as it does, current at 1000 volt. Many people would consider 1000 volt too high a potential for safety in a mine, and if this were reduced to 500 volt, the cable would have cost twice as much as it did.

To take up the question of loss of power in transmission; electric and air-transmission lines should be calculated in exactly the same way, that is, the size of the conductor or pipe should be in either case such that an increase in size would not save enough power to pay the interest on the added investment. Therefore, if the cost of the transmission-lines were the same in the two cases, the loss in power-transmission would be the same. As a matter of fact, it is too often the case that the superintendent or foreman "guesses" that "a four-inch line will carry it" in the case of an air-pipe, but when it comes to an electric line, about which there is something mysterious to many people, the services of an electrician are called in, and he figures the size by formula. But this state of things does not change the facts, that the loss of power in transmission should be no more in the case of compressed-air than in that of electricity, and that it costs about as much for electric-cables as it does for air-pipes. I might add that a poorly constructed electric-line will leak power as well as a poorly constructed air-line.

ARTHUR B. FOOTE.

Grass Valley, Cal., August 3.

A BELATED PATENT

It is a well established fact that certain air compressors, notably those of the piston inlet type, fill their air cylinders on the intake stroke with air fully up to and often slightly above the pressure of the surrounding atmosphere. This is shown by indicator cards, in which the compression line at the beginning of the compression stroke is sometimes coincident with and sometimes perceptibly above the atmosphere line, although through most of the intake stroke it is necessarily low enough to cause the atmospheric pressure to drive it into the cylinder. It is not difficult to account for this complete filling of the cylinder precisely when the reversal of operations occurs, when we consider that the air comes in with a rush through a long pipe or passage and that the sudden checking of the inflow at precisely the end of the stroke causes the inertia of the rapidly moving column to assert itself by a final thrust upon the air immediately in advance of it.

This being so, it is difficult to understand how any man sufficiently informed to become an inventor in this line could have "invented" precisely this operation and the means by which it is effected a score of years after it has become a familiar accompaniment of established practice, or how the examiners of the U. S. Patent Office could have allowed patent No. 899,706 reported upon the last page of our present issue. This a patent for a "Method of Increasing the Volumetric Efficiency of Cylinder and Piston Machines," the inventor living in London. A single claim of the patent tells the whole story:

"A method of increasing the volumetric efficiency of cylinder and piston machines drawing in charges of elastic fluid," [air] "which consists in causing the suction to occur through a pipe of such length that the pressure at the inlet port at the moment of closing is greater than the normal pressure of the fluid at said port."

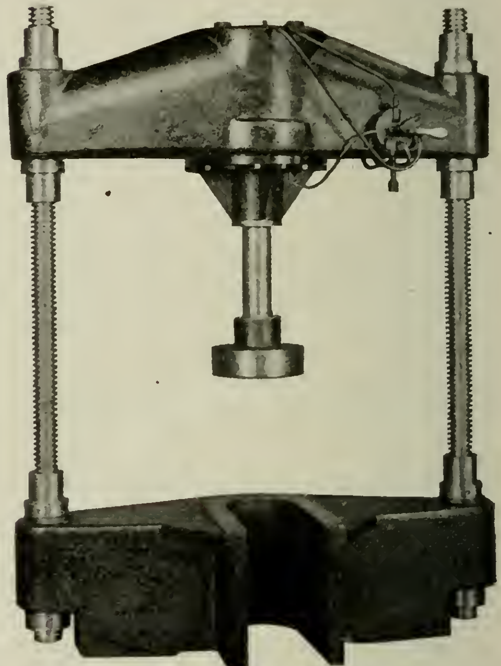
This might very properly have constituted a claim of the original piston inlet patent, so that the value of the patent above referred to must be purely imaginary.

AN INTENSIFYING PNEUMATIC PRESS

The press shown in the half-tone speaks for itself as to its general design and adaptability. It was built originally by the Springfield Machine Tool Company, Springfield, Ohio, for use in its own factory, and is now manufactured for general use in machine shops or elsewhere.

The press as here shown is large enough to take a 40-inch wheel between the uprights. The opening in the centre of the heavy base permits the placing of the work in position without lifting and dropping into a hole. The opening extends back beyond the centre line of the machine. The screws of course allow the head to be raised or lowered according to the height of the work. The head, which is designed to be of equal strength with the base, contains a 12-inch cylinder with 8-inch travel of piston. The piston has three packing rings which effectually prevent air leakage. The heavy shoe on the end of the piston rod has the central portion of its face filled with babbitt, so that work will not be bruised when pressure is applied. The babbitt may of course be renewed whenever necessary.

The press is completely controlled by the valve shown at the right. This directs the air both above and below the piston. Moving the handle from the left hand position the piston may be raised, and a further movement in the same direction shuts off the air. Passing the next point in the same direction applies the full pressure to the top of the piston. With the usual shop air pressure of say 80 lbs. the total pressure will be nearly 9,000 lbs.



INTENSIFYING PNEUMATIC PRESS.

If a greater pressure than this is desired a further movement of the valve handle in the same direction throws into operation a small, quick acting air pump, which is placed on top of the frame and not shown in the half tone. This pump will raise the air pressure to 250 lbs., and thereby increase the total piston pressure to 27,000 lbs. The pump is a very small arrangement receiving the working pressure upon one side of the pump, the piston of which automatically reciprocates, carrying on its other end a smaller piston which increases the pressure more than threefold. The pump in principle is similar to a boiler feed pump with steam and water cylinders of different diameters. The press has been thoroughly tested in actual service, and has proved in every respect satisfactory.

MUNICIPAL MUNIFICENCE

After working for a period of 16 years, seven days in the week, as chief engineer at the pumping station of Cedar Falls city water works, H. C. Boyson has been granted a two weeks' vacation by the city council at full pay with the privilege of a month should he so desire. During the sixteen years Mr. Boyson has been in charge of the city pumping station he has worked alternately day and night and has never lost a day because of sickness, accidents or for any other reason. He started in at $40 a month and has gradually been advanced by the city council until he now receives $60.00.—*Midland Municipalities.*

MOIST AIR DRYING

Moist-air drying is growing from the fact that it is becoming understood that it is not the amount of moisture in the air, but the amount more that can be put in, that makes it a drying air. With the fact that each advance in temperature of 25 degrees doubles the capacity of the air for moisture, it may be readily seen that moisture in air of a considerable amount at any given temperature, when that temperature is raised, is no longer a large factor in the capacity of that air to receive more moisture. It also should be borne in mind that water in all its forms, vapor or steam, holds very much more heat for a given volume than will air, therefore hot, moist air holds very much more heat present to supply the needed heat for evaporation than can dry air. Its advantages are very many, not the smallest being the fact that it intercepts the direct heat ray, preventing carbonization of the stock at all stages of the drying, this heat ray, intercepted, also adding to the economy of drying in helping to provide the heat for evaporation, which otherwise is absorbed by the wall, ceiling or floor of the kiln.—*The Wood Worker.*

BUYERS' COMMISSIONS

From the standpoint of the engineer, acting as a purchasing agent or adviser, the case seems to me as clear in the court of honor as it would be in a court of law. He cannot honorably accept a commission from the seller while he is the agent of the buyer. If the custom of the trade permits the giving of such a commission, but not its deduction from the face of the bill rendered, he may, of course, honorably accept it and pay it over to his own employer—that being the only way in which he could secure the minimum net price in his employer's interest—but even in that event he should place his honor beyond suspicion, as, for instance, by demanding the commission in a check to his own order and endorsing the same check to the order of his employer. There may be exceptional cases in which the taking and keeping of a commission is justifiable, but one thing is clear beyond dispute: It is always wrong when it needs to be kept silent.—*John Hays Hammond, Presidential Address at Chattanooga.*

BUBBLES OF GAS SINKING IN A LIQUID

If one were asked to specify a physical law to which there could be no possible exception it might well be that of the rise of bubbles to the top of any liquid. The exception to this, however, has been found. A writer in *Cosmos* says: "We are used to thinking of gases as always less dense than liquids, and, in fact we have never hitherto been able to increase the density of a gas, either by compressing or by cooling, down to the point where it becomes heavier than a liquid in contact with it. This could not take place, of course, if the gas became liquid or dissolved in the liquid. Dr. Kammerliugh Onnes has, nevertheless, accomplished this surprising feat by causing a bubble of compressed helium to descend by its own weight through liquid hydrogen, like a drop of water in oil. He compressed a mixture of hydrogen and helium in a capillary tube plunged into liquid hydrogen. The hydrogen becomes almost entirely liquefied and, if the pressure does not exceed 49 atmospheres, occupies the bottom of almost pure helium, which is floating on the liquid, is seen to descend below it, and to rise again when the pressure is decreased to 32 atmospheres.

RAPID DREDGING

The easiest money I ever earned was when I agreed to dredge the ferry slip of the ——— Transportation Company. They were in a bad plight, telegraphing everywhere for a dredger that could be towed up in a hurry; for the river had silted up their landing slip in their busiest season and it meant a thousand dollars a day to them. In the midst of their excitement, I happened into their office and offered to dredge the slip for $500. "Done," said they, and we signed papers on the spot. Then I went out and hired a big tug for five dollars an hour, backed her into the slip, tied her close and fast, and started the engine. In about a minute that big propeller set up such a current that the silt began floating out of the slip in tons. In two hours I called at their office again, left a good cigar, and got my $500.—*Benjamin Baker in Scribner's Magazine.*

NOTES

The highest mine in the world is the Santa Barbara, Bolivia, South America, which is at an altitude of 18,000 ft. above sea level.

In preparing pure white table salt from rock salt the process employed, from the days of the Romans, has been that of solution and evaporation. An English inventor has devised a process, commercially practicable, by which the salt is purified more directly. The salt is simply melted and then compressed air is driven up through the molten mass. Impurities are separated and deposited and the salt is left white and pure. The salt thus produced is said to be exceptionally fine, and, being anhydrous, does not cake.

The Burlington Railroad has recently bored an artesian well at Edgewater, South Dakota, with highly satisfactory results. A geologist of the United States Geological Survey, who had made a study of the surface outcrops of the region stated that a good supply of water would be found in a certain stratum of rock which lay at a depth of about 3,000 feet. When the bore reached a depth of 2,980 feet water rushed out at the rate of 350 gallons per minute, or about half a million gallons a day, supplying a most urgent need of that section.

The vacuum machine, as used for cleaning carpets and house and office furnishings, is now used also for cleaning horses. The apparatus comprises a vacuum pump with means for driving it, a vacuum tank with gage and separating diaphragm a number of special vacuum combs and connecting pipes and tubing. A horse can be thoroughly cleaned in one quarter the time required by hand.

The rifled oil pipe line of the Southern Pacific Co. in the San Joaquin valley, California, is now in operation for a length of 120 miles. It is to be extended to nearly 300 miles. Reports state it to be entirely successful, with a movement of 17,000 barrels per day (8in. pipe). There are eight pumping-stations on the line. The water which is pumped in forms an outer skin about 1-8 in. thick at the beginning and thicker farther along the line, the oil staying in the interior, due to centrifugal action (as in cream separators).

An act of revenge on the part of an Italian laborer, because he considered he had been dismissed without cause, has cost the government of Baden the sum of $875,000. The government has been constructing a railroad tunnel through the Black Forest Mountains, working in from each end to meet in the centre. It was discovered to-day that the two halves, which should have come together at the village of Forbach, miss each other by twenty-six feet. The reason is a mistake in the survey which arose from the intentional misplacing of a surveying pin by the Italian.

Last year coal was mined in 3,295 mines in Great Britain, as against 3,461 in 1902. The number of coal-cutting machines at work was 1,136 as against 483 the preceding year, a gain during this period of 653 cutters. It is apparent that machines are rapidly growing in favor. The motive power is still a debatable point. In Scotland electricity is the favorite, 171 machines being driven by electricity and 134 by compressed air. In England compressed air is the favorite, in one district the disparity being as great as 158 compressed-air machines to 94 driven by electricity. The machine-mined coal in 1906 was 10,202,506 tons. One ton in every 25 was mined by machinery.

In a tunnel which is being driven to connect the Rausch Creek workings with the big Brooksile colliery of the Philadelphia & Reading Coal and Iron Company, two men were recently killed by lightning a quarter of a mile from the entrance. The electric connection with the outside was probably through the rails.

A new electro-barograph has been invented to furnish an automatic and audible signal in case of a sudden and dangerous drop of mine pressure. It consists of an aneroid barometer, fitted with three dry cells and a signal bell. The contact-maker may be adjusted at the beginning of each shift, or at any other appointed time. The distance between the pointer and the brush or contact-maker is adjusted to the requirements of each mine. As soon as the bar of the barometer falls a certain distance, measured by the interval between the pointer and the brush, electric contact takes place between the bar and the brush, and the bell rings.

The production of hydrogen by a new and cheap process is reported from Germany in a Consular Report from Chemnitz. The method which has been devised by a German professor, is said to have aroused considerable interest among aeronauts and manufacturers who use hydrogen in the arts. The materials employed in the new process are water, coke and calcium carbide. The first step is the production of water gas, which is obtained by passing steam through a thick bed of red-hot coke, and consists principally of a mixture of hydrogen and carbon monoxide. The latter is removed by passing the water gas over glowing calcium carbide in the form of powder. The carbon monoxide is completely decomposed, uniting with the carbide to form lime and pure carbon, and leaving the hydrogen isolated with an admixture of but one per cent. of other gases.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

SEPTEMBER 1.

897,290. PNEUMATIC EYE-PROTECTOR. ALBERT E. JACOBS, Lancaster, Pa.

1. In a device of the class described, consisting of an eye protector, a frame formed of two adjacent tubular circular eye frames formed with openings in their periphery, a tubular nose-bridge connecting said eye frames, means for connecting said eye frames to flexible piping, and means for supporting said flexible tubes and securing the device to the head of the wearer, for the purpose set forth.

897,356. METHOD OF DRYING AIR FOR BLAST FURNACES. DAVID T. DAY, Washington, D. C.

897,484. PNEUMATIC CONTROL SYSTEM. PHILIP PFORR, Berlin, Germany.

897,491. ACETYLENE - GAS APPARATUS. NILS A. RENSTROM, Omaha, Neb.

897,498. MULTISTAGE PUMP FOR PRODUCING A VACUUM OR COMPRESSING GASES. AUGUST SIEGEL, Berlin, Germany.

897,593. APPARATUS FOR CONTROLLING THE FLOW OF LIQUIDS. JAMES W. COX, Berwyn, Ill.

897,657. ELECTRIC AND PNEUMATIC GOVERNOR. WILLIAM K. RANKIN, Philadelphia, Pa.

897,666. METHOD OF CONTROLLING AIR-SHIPS. MARIO SCHIAVONE, Ferrandina, Italy.

897,676. FLUID-FEEDING-PRESSURE MECHANISM. GEORGE THOMPSON, Mansfield, Ohio.

897,811. AUTOMATIC PNEUMATIC-TIRE INFLATER. ROBERT C. BARRIE, Philadelphia, Pa.

897,813. AIR-GUN. BURTON B. BENNETT, Detroit, Mich.

SEPTEMBER 8.

897,923. PROCESS OF PRESERVING EXPLOSIVES. JULIEN ORTIZ, Greenville, Del.

1. The process of storing explosives to retard their spontaneous decomposition which consits in inclosing a quantity of the explosive in an air tight compartment, rarefying the air in the compartment in contact with the explosive and displacing the withdrawn air with a body of anhydrous air, and then rarefying the body of anhydrous air.

897,958. PNEUMATIC HAMMER. JOSEPH BOYER, St. Louis, Mo.

898,015. AIR-LIFT PUMP. WILLIAM F. SPANGLER, Greenfield, Ind.

898,022. FLUID-PRESSURE BRAKE. CLARENCE A. TRIPP, Los Angeles, Cal.

898,096. AIR BRAKE COUPLING. JOEL H. COLE, Arkansas City, and JOEL R. COLE, Winfield, Kans.

898,135. VALVE-OPERATING DEVICE FOR COMPRESSORS. WILLIAM PRELLWITZ, Easton, Pa.

898,194. AUTOMATIC GOVERNOR FOR PNEUMATIC MOTORS. CHARLES L. DAVIS, Detroit, Mich.

898,214. AUTOMATIC PIPE-COUPLING FOR RAILWAY-CARS. EDWARD E. GOLD, New York, N. Y.

898,264. HYDRAULIC AIR-PUMP. JOHN B. RIDOUT, St. Paul, Minn.

898,343. AIR-LOCK FOR MINES AND TUNNELS. PATRICK H. DURACK, El Paso, *Tex.*

898,363. INTERCOOLER. FRED D. HOLDSWORTH, Claremont, N. H.

898,389. AIR-COMPRESSOR. FREDERICK W. PARSONS, Tarrytown, N. Y.

SEPTEMBER 15.

898,444. APPARATUS FOR SUBJECTING MATERIALS TO THE ACTION OF LIQUID UN-

DER PRESSURE. Leon Detre, Rheims, France.

1. In an apparatus for subjecting textile or other materials to the action of liquids under pressure, in combination, a reservoir for the liquid, means for maintaining a pressure on the liquid in said reservoir, a vessel for the material and in communication with said reservoir so that the pressure facilitates the penetration of the liquid into or through the material, and means acting independently of the degree of pressure for sucking out the liquid at one side of the material in the vessel, and forcing it in at the other.

898,461. VACUUM-PUMP. William P. M. Grelick, Elgin, Ill.

898,493. ROTARY AIR-PUMP. Harry M. Montgomery, Chicago, Ill.

898,505. PNEUMATIC HAMMER. Theodore C. Prouty, Aurora, Ill.

898,506. APPARATUS FOR THE PRODUCTION OF OZONE. John R. Quain, London, England.

898,522. POWER AIR-PUMP. Williard J. Spencer, Waterbury, Conn.

898,524. DEVICE FOR SUPPLYING FIREMEN WITH FRESH AIR. Patrick H. Sullivan, Detroit, Mich.

898,542. PNEUMATIC - DESPATCH - TUBE SYSTEM. Franklin H. Wolever, Chicago, Ill.

898,601. PROCESS OF MANUFACTURING GAS. Hawley Pettibone, New Rochelle, N. Y.

898,606. AUTOMATIC GOVERNOR FOR FLUID-COMPRESSORS. Edward J. Rohrbacher, Blaine, Wash.

898,612. COMPRESSED-AIR WASHING DEVICE. Joseph A. Vance, Columbus, Ohio.

898,659. COMPRESSOR. Henry Kuehl, Philadelphia, Pa.

898,679. BRACE ATTACHMENT FOR FLUID-PRESSURE-OPERATED TOOLS. William Prellwitz, Easton, Pa.

898,702. HAMMER-DRILL. Albert H. Taylor, Easton, Pa.

898,712. PNEUMATIC VEHICLE-SPRING. Truman G. Wilkinson, South Williamsport, Pa.

898,746. DOUBLE-ACTING WET-AIR PUMP. Emil Josse, Berlin, Germany.

989,761. PNEUMATIC ACTION. Hermann Meyer, New York, N. Y.

898,775. AIR CONVEYER. Edwin Norton, Lake Placid, N. Y.

1. The combination of a sheet or pack rolling mill, an air conveyor for the hot rolled sheets or packs, said air conveyer comprising a casing provided with air ducts constructed so as to direct air from the casing upwardly against the sheets or packs and forwardly in the direction in which the same are to be conveyed, and means for artificially cooling the air before it is discharged against the said sheets or packs being conveyed.

898,856. DRY-PIPE VALVE. Powell Evans, Philadelphia, Pa.

898,927. VACUUM MINING DEVICE. Jerry B. Riddle, Sacramento, Cal.

SEPTEMBER 22.

899,027. ROTARY AIR - COMPRESSOR. George F. Burton, Woodlawn, Ala.

899,101. CONTROLLER FOR PNEUMATIC PUMPS. Elias W. Conkell, Canton, Ohio.

899,110. AUTOMATIC AIR-VALVE. George D. Hoffman, New York, N. Y.

899,225. RESPIRATION APPARATUS. Peter Lord, Worcester, Mass.; Martha V. Lord administratrix of said Peter Lord, deceased.

899,246. AUTOMATIC SANDING APPARATUS FOR FLUID-PRESSURE BRAKES. Edward G. Desoe, West Springfield, Mass.

899,263. AUTOMATIC PRESSURE-GOVERNOR. George M. Richards, Erie, Pa.

899,289. APPARATUS FOR PURIFYING AND HUMIDIFYING AIR. William G. R. Breamer, *Buffalo*, N. Y.

899,427. AIR-BRAKE SYSTEM. James D. Nichol, Amadore, Mich.

899,458. PUMPING APPARATUS. George J. Murdock, Newark, N. J.

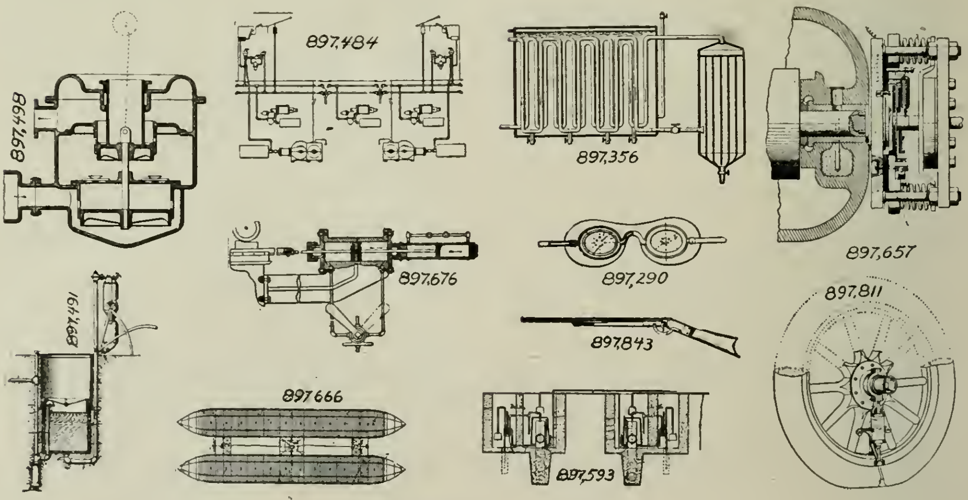
1. In pumping apparatus such as described, an air chamber provided with an inlet and with an outlet, separate from said inlet, for the fluid to be pumped, in combination with a source of supply of pulsations of fluid under pressure, and means connecting the same to the interior of said chamber at a point below the top thereof.

899,462. AIR - VALVE FOR HYDRAULIC JACKS. James W. Nelson and William H. Mathers, New York, N. Y.

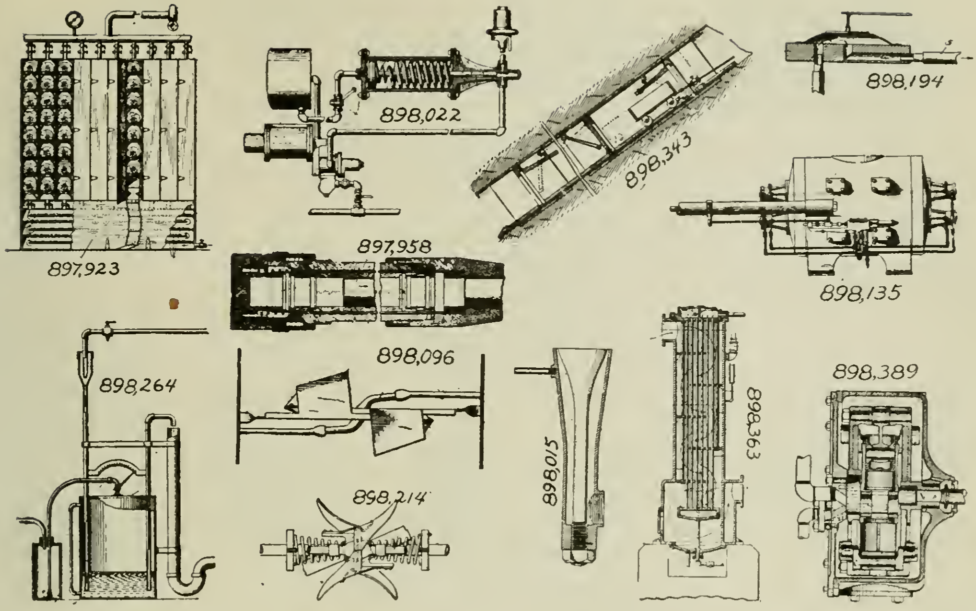
899,480. PRESERVING WOOD. Walter Buehler, Minneapolis, Minn.

12,857. (Reissue). VALVE. William H. Kline, Dunbar, Pa.

1. In a device of the character described, storage reservoir, a fluid compressor provided with a port to admit fluid under pressure from the



Pneumatic Patents, September 1.



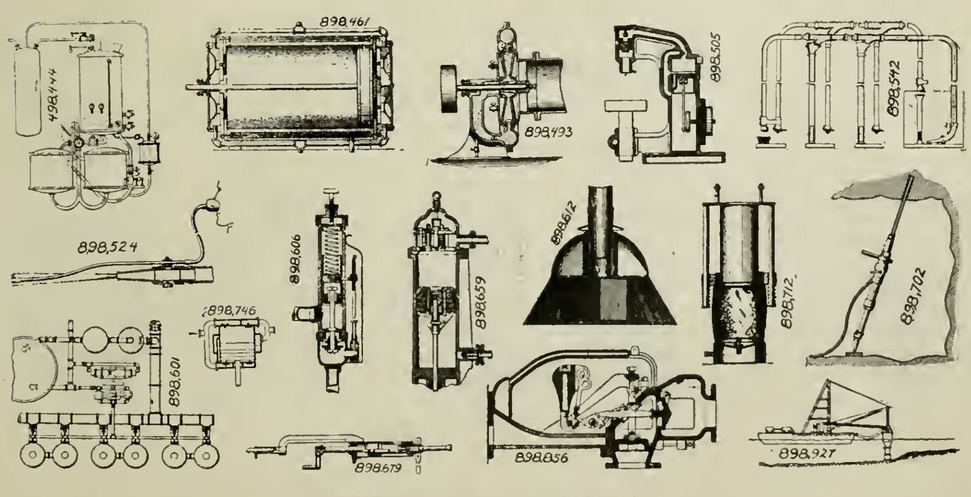
Pneumatic Patents, September 8.

compressor to the reservoir, a port-closure adapted to control the flow of fluid through the port and from the compressor to the reservoir, a piston adapted to operate said port-closure, a cylinder in which said piston is mounted to reciprocate, a pipe disposed to admit a fluid under pressure from the compressor to the cylinder to operate the piston, a valve located in said pipe, and means for admitting a fluid from the reservoir to hold the said valve normally closed, the parts being so disposed that, when the tension of the fluid in the compressor exceeds the tension of the fluid in the reservoir, the valve is opened to admit fluid to the cylinder.

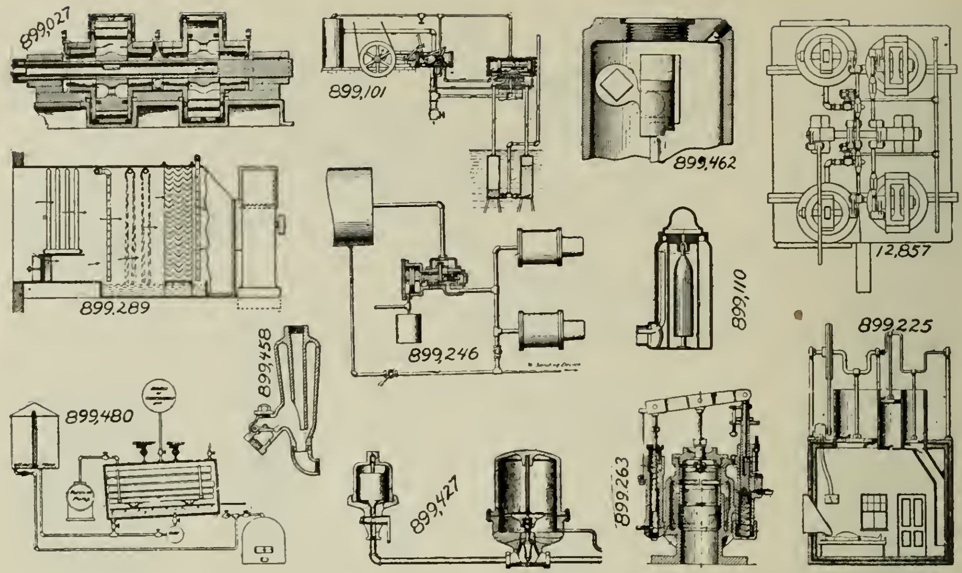
SEPTEMBER 29.

899,508 MEANS FOR VENTILATING MINES AND REMOVING DUST AND GASES THEREFROM. Frank T. Byers, Mount Pleasant, Pa.

1. Apparatus for the ventilation of mines and the removal of dust and gases therefrom, comprising means for closing the entrance of the mine, means for reducing the atmospheric pressure therein, means for introducing air at a higher pressure into the inner ends of the chambers or rooms, thereby causing drafts from the rooms into the headings of the mine, and means for conducting the dust and gases from the head-



Pneumatic Patents, September 15.



PNEUMATIC PATENTS, SEPTEMBER 22.

ings into dust settling and collecting chambers.

899,551. WEIGHING APPARATUS. HENRY B. MORRIS, Grand Rapids, Mich.

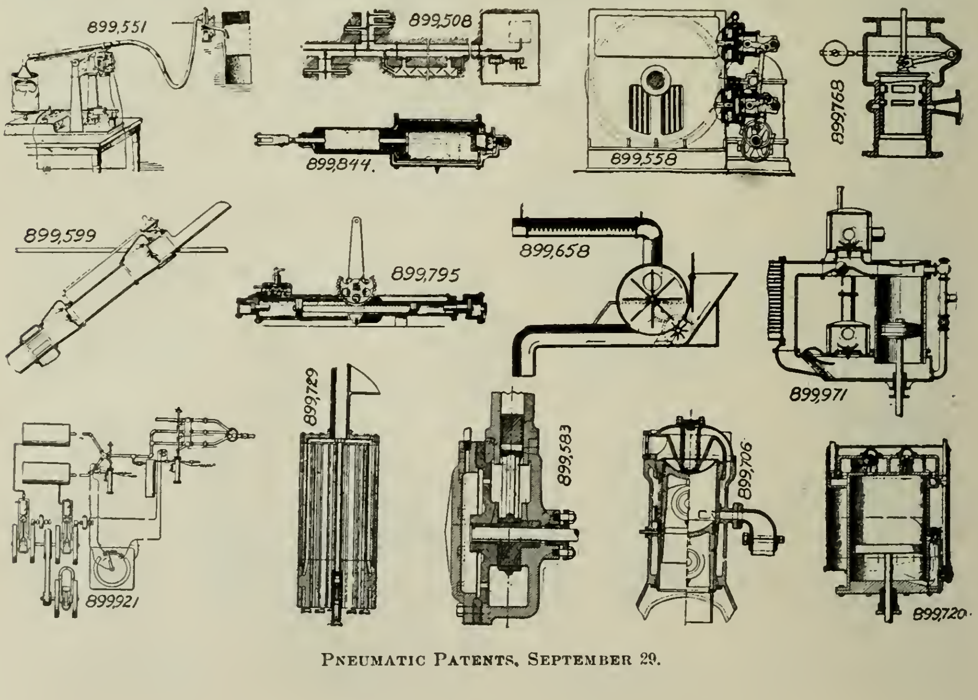
1. An apparatus for obtaining accurate weight, comprising scales on which a filled receptacle is supported, means adapted to be inserted into and withdrawn from the upper part of the receptacle while on the scales to withdraw surplus material from the upper surface thereof, and devices for arresting the withdrawing action when the desired accurate weight has been obtained.

899,558. BLOWING-ENGINE. GUSTAVE B. PETSCHE, Philadelphia, Pa.

899,583. GAS-PUMP. RICHARD WHITAKER, New Brunswick, N. J.

899,584. VALVE FOR GAS-PUMPS. RICHARD WHITAKER, New Brunswick, N. J.

899,599. SENDING MECHANISM FOR PNEUMATIC-DESPATCH SYSTEMS. CHESTER S. JENNINGS, Boston, Mass.



PNEUMATIC PATENTS, SEPTEMBER 29.

COMPRESSED AIR
MAGAZINE
EVERYTHING PNEUMATIC.

Vol. XIII DECEMBER, 1908 No. 12

COMPRESSED AIR AT HIGH ALTITUDES

Why More Air is Required—Simple Methods for Calculating the Power Needed for Compressing.

By S B. Redfield.

Most users of compressed air are aware of the fact that at high altitudes, such as a mine located in mountainous country, a greater quantity of compressed air at a given pressure is required to do a given amount of work, such as rock drilling, than would be required to do the same amount of work at sea level.

Furthermore, the catalogues of the various makers of air compressors give lists of special compressors with extra large cylinder diameters, for altitude work. These tables show that the higher the altitude, the greater the volume of air that may be compressed to a given gage pressure with an equal amount of work. Thus it appears that while more air is required to do a given amount of work at a high altitude, more air may be compressed to a given pressure at that altitude with a given amount of power, and the question naturally arises as to whether or not these two effects neutralize each other with the result that the total actual amount of power required to do work at a high altitude may remain the same as at sea leved. In reality these two effects do not neutralize each other, and in studying this question, the diagrams presented will serve to clearly show the actual conditions.

THE REASON WHY.

Before arriving at final results, a study of the "reason why" will be of interest. In the first place, why does it take more air at a high altitude to do a given amount of work? The first and most obvious answer to this question is that the air is "rarer" at a high altitude. This is a good, general answer when air-operated machinery is viewed as a heat engine, but it does not give a sufficient explanation for most people.

Work is the product of a force through a distance. Suppose the working medium is compressed air, and, naturally, that it exerts its pressure against the face of a piston. Then the product of the air pressure by the area of the piston will give the "force," and the travel of the piston will give the "distance," resulting in work accomplished. Of course, the air must have a definite pressure, the piston a definite area and the travel must be defined in order to do a definite, measured amount of work. The actual air pressure which does the work is the difference between the absolute pressure on one side of the piston, and the atmospheric pressure on the other side; in other words, it is the gage pressure. Now it is the atmospheric pressure which changes at high altitudes, and it is this that makes all the difference in air required and power developed.

As it is the gage pressure which actually does the work, a given gage pressure will exert the same force on an equal piston area at any altitude. For instance, 100 pounds gage pressure per square inch acting on a piston area of, say, 100 square inches, will exert a total force of 10,000 pounds, no matter what the altitude or atmospheric pressure may be.

This may be viewed in another way. At sea level 100 pounds gage pressure will be 114.7 pounds per square inch absolute, and acting on 100 square inches will exert 11,470 pounds pressure on one side of the piston, while the atmosphere will exert 14.7 pounds per square inch absolute on the other side, or 1,470 pounds pressure. The resultant force is 11,470 — 1,470 = 10,000 pounds urging the piston on. If the altitude were 8,000 feet above sea level and the atmospheric pressure were 10.9 pounds absolute, 100 pounds gage pressure would be 110.9 pounds absolute, and acting on 100 square inches of piston area the total force exerted would be 11,090 pounds, while the atmosphere on the other side would exert a pressure of 10.9 pounds per square inch, or 1,090 pounds upon the back of the picton. The esultant force is 11,090 — 1,090 = 10,000 pounds tending to move the piston, as before.

From this it is seen that the change in atmospheric pressure due to altitude has no effect whatever on the net force exerted upon a given piston area by a given gage pressure. Then why is more air required to do work at a high altitude? The cause lies in the volume of compressed air The quantity of compressed air required to fill a given space depends upon the pressure of the air, and it is the absolute pressure to which it is directly proportional.

Again, let us assume 100 pounds gage pressure and 100 square inches of piston area and let the distance moved through be 1 foot. Then no matter what the altitude, the total force exerted will be 10,000 pounds, as already shown, and moving through 1 foot of distance the work performed will be 10,000 foot-pounds. The quantity of free air required to do this work nonexpansively will be the volume of the cylinder multiplied by the absolute ratio of compression of the air, or the number of times it has been compressed. At sea level, the ratio of compression would, in this case, be 114.7 ÷ 14.7 = 7.8. The volume of the cylinder we are considering is 1,200 cubic inches, or 0.694 cubic foot, so the total quantity of free atmospheric air that would be used at sea level would be 0.694×7.8=5.42 cubic feet.

If this had been done at, say, 8,000 feet altitude, and the atmospheric pressure were 10.9, the ratio of compression would have been 110.9 ÷ 10.9 = 10.16. Then the total quantity of free atmospheric air that would have been used at 8,000 feet altitude would be 0.694 × 10.16 = 7.05 cubic feet.

By this it is seen that while at sea level 5.42 cubic feet of free atmospheric air acting at 100 pounds gage pressure will do 10,000 foot-pounds of work, it will require 7.05 cubic feet of free air to do the same work acting on the same piston at 8,000 feet altitude. This is an increase of 30 per cent of free air or piston displacement of compressor required, and is, of course, based on nonexpansive operation, as is usually the case with air-operated machinery.

POWER REQUIRED TO COMPRESS THE AIR.

Now to look at the matter of the power required to compress this increased quantity of air at a high altitude. The formula for the power required to compress 100 cubic feet of free air per minute to any pressure is, for single-stage compression:

Indicated Horsepower=

$$1.51\ p_1 \left(R^{0.29} - 1\right).$$

For compound compression the formula is:

Indicated Horsepower=

$$3.02\ p_1 \left(R^{0.145} - 1\right).$$

In these formulas p^1 is the absolute initial pressure per square inch at the inlet to the compressor, usually that of the atmosphere, and R is the ratio of compression, or the absolute discharge pressure divided by the absolute initial pressure. This shows that the power required to compress a given cylinder volume of air to any pressure depends upon the initial or atmospheric pressure. As this factor appears in the formulas both outside the bracket, to the first power, and also in the ratio of compression raised to a fractional power, it is plain that the power required will not vary in a simple ratio with the intake or atmospheric pressure. As the quantity of air required to do a certain amount of work does vary directly with the ratio of compression, which is dependent upon the atmospheric pressure, it is clear that the one does not increase at the same rate at which the other decreases, and the net result of power required to do a certain amount of work by compressed air will vary with the atmospheric pressure and therefore with the altitude.

By figuring out the amount of air required and the amount of power required to compress this air, to do a given amount of work, at various altitudes, it will be found that the higher the altitude the more power it will take to do this work. Of course the pressure of the air has some bearing on the subject, but it is a fact that within the limits of usual pressures employed, the increase of power varies very little with the air pressure, at a given altitude.

The curves given in Fig. 1 show how the free air, or compressor-piston displacement, and the power required increase with the altitude. The increase is given in percentage of that required at sea leved. The curves of piston displacement increase are calculated with both 100 pounds and 80 pounds gage pressure at the drills, and the curves of power increase are calculated with 100 pounds gage pressure at the compressor, as a basis. It should be understood that this latter pair of curves does not show the change in power required to compress a given amount of air, but that it does show the increase of power required in the compressor to do a given amount of work in such a device as a rock drill, or other reciprocating machine, operated by compressed air without cutoff or expansion. The full-line power curve shows theoretical results, counting or using the air in the drill at exactly the same pressure as that of the compressor discharge, or in other words, without pipe-line pressure drop. The broken line is calculated on a basis of using the air in the drill at a pressure 20 pounds below that of the compressor.

From these power curves it appears that at 10,000 feet altitude, with no pressure drop, the power required is 15.2 per cent. more than at sea level, while if 20 pounds pipe-line pressure drop is allowed, the increase is about 14.1 per cent. At 5,000 feet altitude, these figures are 7.25 and 6.85 per cent., respectively. This statement is liable to raise a misunderstanding, for it seems to show that a pressure loss in the pipe line is an advantage, which is against common-sense reasoning.

As a matter of fact, the full-line and broken-line power curves in Fig. 1 should not be compared with each other, for any point on either curve is relative to other points on itself only. The actual power required at any altitude with 20 pounds pressure drop in the pipe line is, of course more than that required without any pressure drop, but at a higher altitude the *increase* of power required, due to that altitude, is less than when there is none. This is easy to see when it is remembered that a given measured increase of power would be a smaller percentage of the larger power, and it is, of course, advisable to have as little pressure loss in the pipe line as is possible. The curves are figured on compound compression because this is the most usual, especially for altitude work, where the ratio of compression increases considerably, giving rise to high cylinder temperatures.

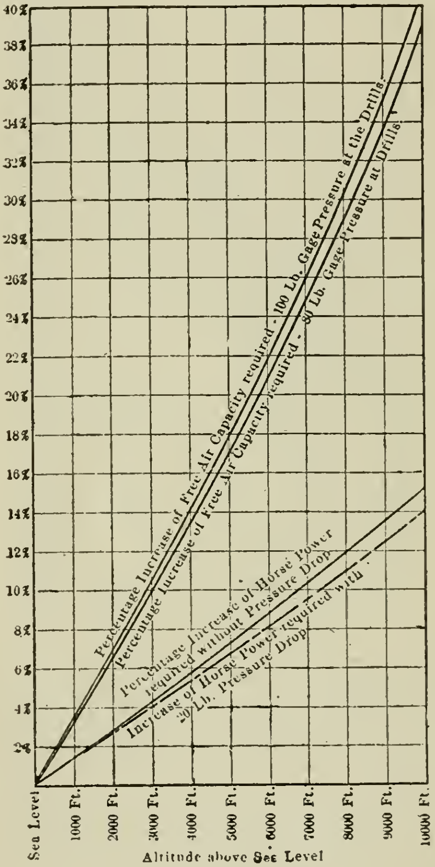


FIG. I

The most useful feature of this discussion will be found in Figs. 2, 3, and 4, where curves are plotted to show how the indicated horsepower required to compress 100 cubic feet piston displacement of free air per minute varies with the pressure at different altitudes, and also how it varies with the altitude at different pressures. These two sets of curves viewed together reveal the rather curious fact that although the indicated horsepower at a given altitude varies with the pressure in a curved line, the variation with the altitude at a given pressure looks like a straight line (Fig. 4).

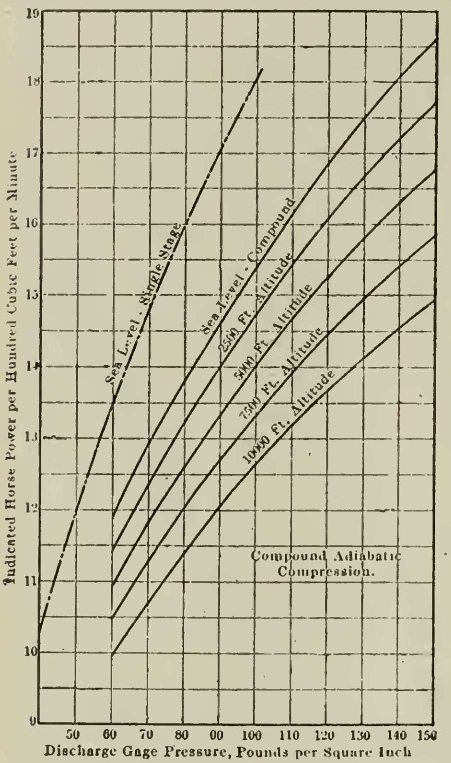


FIG. 2

These lines are, however, not straight, for when the calculations are carried through a wider range of intake pressure variation, it is found that the lines begin to curve to a very marked degree. This is shown in the two lower curves of Fig. 6. In this figure, horizontal distances represent absolute initial pressure at the compressor intake, and the marking on the various curves clearly indicates what they each represent. All the calculations illustrated in Fig. 6 are based on 100 pounds gage, compressor-discharge pressure, assuming the atmospheric, or initial-intake pressure, to vary from zero or absolute vacuum, to a maximum of 300 pounds absolute.

These curves, then, may be taken to show what would occur in caisson work, where drills are operated in an atmosphere denser than that existing outside, assuming that the drill compressor draws its air supply from the caisson itself. As before stated, the working pressure is 100 pounds gage at all times; that is a pressure gage placed in the dense atmosphere and connected to the compressor discharge would always read 100 pounds no matter what the absolute pressure of the atmosphere in the caisson. For instance, when the absolute pressure of the caisson atmosphere is 20 pounds, the absolute compressor discharge is 120; when it is 50 pounds the absolute compressor-discharge pressure is 150 pounds, and when the atmosphere is at 200 pounds, the discharge pressure is 300 pounds absolute. Of course, in practice, caissons are seldom or ever operated with an atmosphere above 40 pounds gage, or 55 pounds absolute, so, for

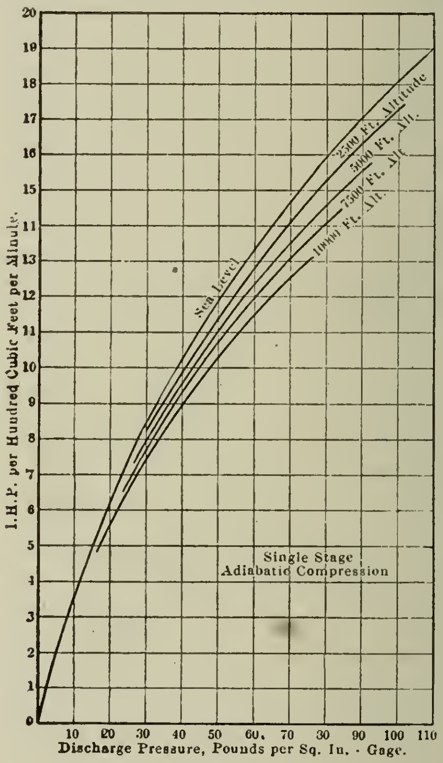


FIG. 3

actual conditions, the curves in Fig. 4 could have been limited between an initial pressure of 10 pounds absolute, for 10,000 feet altitude work and 55 pounds absolute for the heaviest caisson work. However, the calculations were extended from zero to 300 pounds absolute-initial pressure simply to show the trend of the curves.

It will be seen that the curves of the indicated horsepower per 100 cubic feet compressor displacement for single-stage and for compound compression both start at zero indicated horsepower, with zero atmosphere, or absolute vacuum, and as the atmospheric pressure increases they diverge considerably, well showing the saving by compound compression. However, as the atmospheric pressure increases and the ratio of compression becomes less and less (at 14.7 pounds absolute-initial pressure the ratio of compression is 7.8 and at 300 pounds absolute-initial pressure it is only 1.5, assuming always 100 pounds gage discharge pressure), the two lines again come nearer and nearer each other, until they meet at infinity.

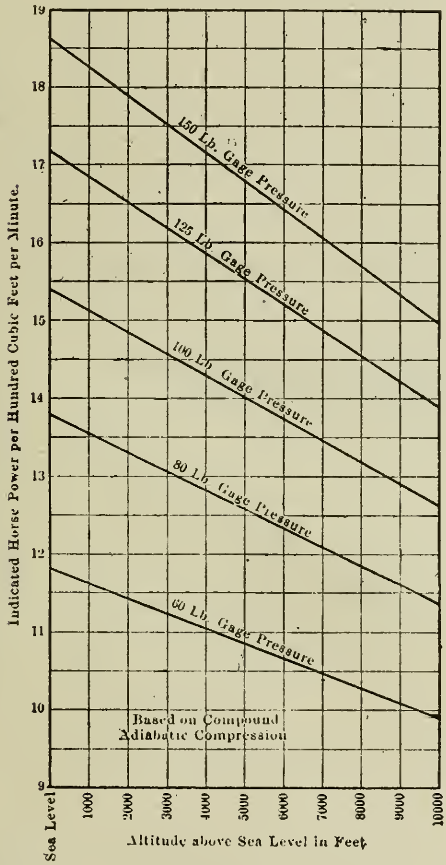


FIG. 4

Above these two indicated horsepower factor curves is another curve showing the compressor displacement required per 100 cubic feet of drill-cylinder displacement, under what might be termed extended caisson conditions. Above this, again, are curves showing the total indicated horsepower required in the compressor per 100 cubic feet of drill-cylinder displacement per minute. This drill displacement may be taken as the measure of the actual work done by the air in the drill, because the working pressure is assumed to always remain at 100 pounds gage. All these lines then show the various requirements of air and power to do the same amount of work in the drills, as the caisson atmosphere is varied from vacuum to 300 pounds absolute.

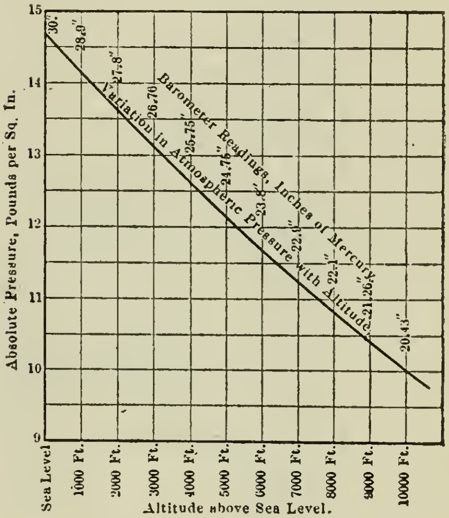


FIG. 5

Assuming single-stage compression, it appears that while the total compressor indicated horsepower per 100 cubic feet of drill displacement per minute is 142 when the atmosphere is at 14.7 pounds absolute, or normal, the compressor power required is only 82 indicated horsepower, or 58 per cent. of this, when the caisson atmosphere is 55 pounds absolute, or 40 pounds gage. Comparing the power required at 55 pounds absolute caisson pressure

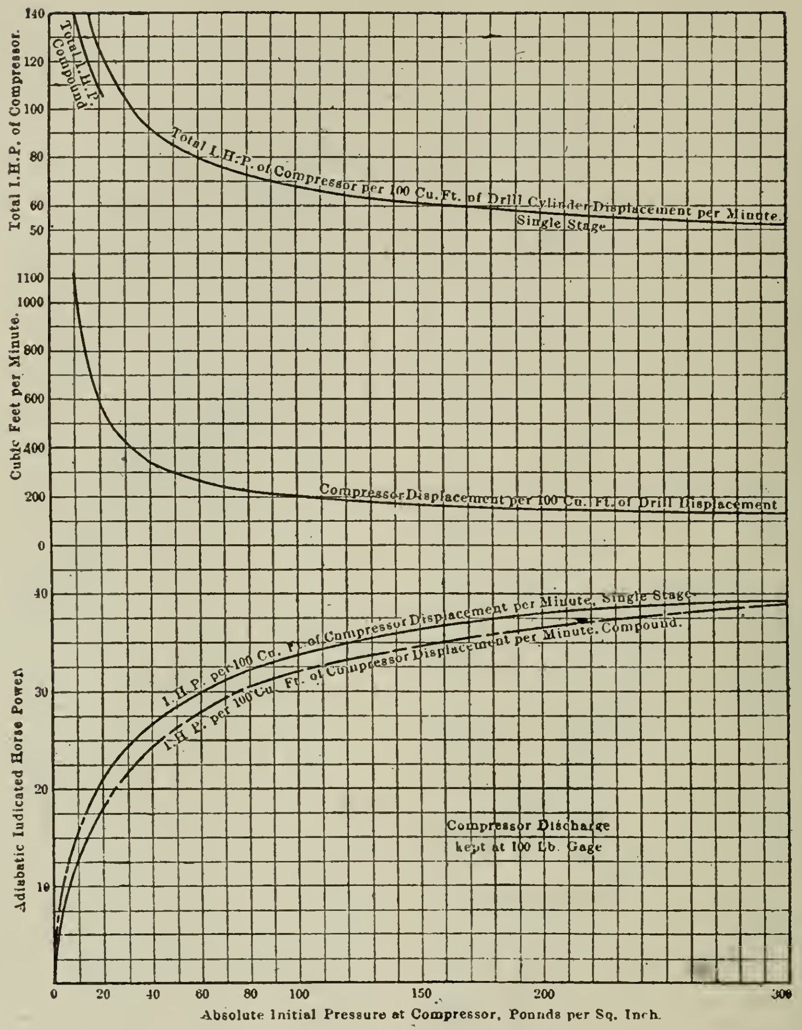


FIG. 6.

by single-stage compression with compound compression at 14.7 pounds absolute-atmospheric pressure, we have 120 for the latter, and 82 for the former, and 82 is 68 per cent. of 120. Compound compression would not pay for an atmosphere above 20 pounds absolute, with 100 pounds gage working pressure, because the ratio of compression becomes too small.

As a matter df fact, in actual caisson work, the compressors driving the drills usually draw their air supply from the natural outside atmosphere and thus add their output, through the drills, to the air being pumped directly into the caisson. It would at first appear that they would save considerable power by drawing the air for the drills from that in the caisson, thus using it over and over again, but of course just exactly the amount of air used by the drills would have to be pumped into the caisson by the low-pressure compressors, to keep out the water, so nothing would be saved by this means after all.

Some attempts have been made to apply this high intake-pressure method of operation to the driving of drills and pumps, and much calculation and writing has been done on the subject, which is known as the "dense-air system." Its theoretical savings are indeed attractive, but it is a difficult system to govern, not being flexible, and the troubles with leakage in the double pipe lines, and many other difficulties, have prevented its extensive adoption. There are, however, some large examples of its use in the South African mines, at the present time.

The curves given in Figs. 2, 3 and 4 will be found useful for figuring the power required to drive a compressor of a given size at any altitude from sea level to 10,000 feet elevation. The figures give theoretical adiabatic indicated horsepowers developed in the compressing cylinders, per 100 cubic feet of piston displacement per minute, and to these should be added about 12 per cent. for a steam machine and 20 per cent. for belt driving, to allow for mechanical efficiency of the moving parts of the machine, belt, etc.

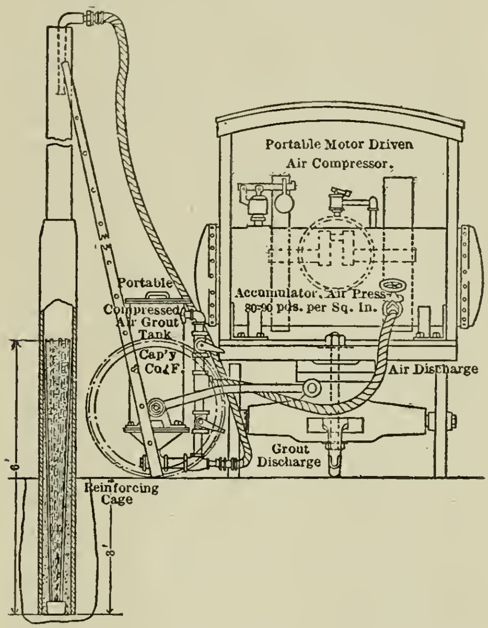
Fig. 5 shows the variation in atmospheric pressure with altitude, from which the other curves were figured. Of course, weather conditions affect the atmospheric pressure quite materially, but the curve is meant to represent average fair-weather conditions.

Fig. 6, while not of direct commercial use, will prove of interest in showing what occurs under various conditions of intake-pressure variation, and if it sheds any additional light on the somewhat complicated subject of air compression, its calculation will not have been made in vain.—*Power and The Engineer.*

REINFORCING CORRODED TROLLEY POLES

One of the largest electric railway companies in this country recently determined to strengthen several thousand trolley poles which threatened to become useless from corrosion. The accompanying cut, from the *Electric Railway Journal,* shows the apparatus employed and a description of the mode of working follows.

The workingmen who reinforce the poles are furnished either with a wagon or a ladder and a vehicle which carries a grouting tank and a motor-driven compressed air outfit operated by current tapped from the trolley wire. In repairing a pole the first step is to remove the cap from the pole and then drop into the latter a reinforcing cage built of high carbon steel twisted bars. At the factory the lower ends of these rods are set in a concrete-iron base, but at the top a hooked cap temporarily confines the upper ends of the rods to allow the cage to pass through the narrower upper section of the pole. Upon the withdrawal of this cap from above the rods flare out against the side of the pole, but are prevented from touching it through the interposition of shims.



REINFORCING TROLLEY POLES.

The next step is to force the concrete into the pole from the grout tank by way of a line of armored hose. When enough concrete to cover the rods has been injected, the pole cap is replaced, and the setting of the concrete does the rest. The size of the rods and quantity of concrete varies, of course, with the degree of reinforcement desired, but in all cases this method brings the advantage of a reinforcement which extends above and below the ordinary limit of corrosion. It has been found that the entire process can be carried out in a few minutes, so that even in the narrowest streets there is no appreciable interference with traffic.

COMPRESSED AIR HYGIENE AND THE ADVANTAGES OF STAGE-DECOMPRESSION

The following is condensed from an elaborate address by Dr. J. S. Haldane before the Society of Arts:

THE EARS FIRST AFFECTED.

When a man is subjected to an increased air pressure his first experience is usually a sense of pressure and discomfort, which may become an acute pain, in his ears. The middle ear is an air cavity communicating by a very restricted passage, the Eustachian tube, with the back of the nose. If this tube does not admit the air freely the pressure in the middle ear is less than outside, the drum membrane is pressed inwards, the blood-vessels of the wall of the middle ear are distended, and rupture of the membrane or bleeding is apt to occur.

Persons differ greatly in the readiness with which their Eustachian tubes pass the air, a peculiar swallowing movement at the back of the mouth will usually greatly assist the operation. To avoid risk of injury the rise or fall of pressure in the air lock must be regulated to the individual susceptibility. One minute or less for atmosphere of pressure change is not too fast for some, but others, particularly new hands, require a much slower rate. It seems desirable to restrict the air inlet to avoid sudden rise of pressure, and the man in charge should see that no one suffers pain.

DISTRESS IN BREATHING.

When a diver reaches a depth of 70 to 90 feet his breathing is much oppressed and his capacity for work is greatly diminished. It has been assumed that the pressure on the body interfers with the breathing, but the carbon dioxide in the air is the real cause. Under normal conditions the breathing is always so regulated as to keep the partial pressure of the carbon dioxide in the air of the lung cells, or alveoli, almost exactly constant. If the barometric pressure varies the percentage of CO_2 varies inversely, so that the pressure of the CO_2 itself remains constant. The respiratory center is, within very wide limits, absolutely indifferent to variations in the pressure of oxygen, the want of it only being responded to when the pressure of oxygen in the air inspired falls below about two-thirds of the normal. If CO_2 is present in the air inspired, the effect is to make the breathing deeper, and finally also more frequent. Unless, however, the pressure of CO_2 in the inspired air begins to approach the normal alveolar CO_2 pressure, there is very little change in this pressure, compensation being produced very easily.

The work involved in pumping compels a diver to content himself with a minimum supply of air. If when he is just under the surface of the water he has enough air to prevent the CO_2 percentage in his helmet air from rising above 3, while he is at work, this will keep him fairly comfortable; but if he now goes down 33 ft., the air supply being the same, the percentage of CO_2 in the helmet air will also remain the same. As, however, the pressure is now two atmospheres, his normal alveolar CO_2 per centage will be 2.8 instead of 5.6.

INCREASE THE AIR SUPPLY.

Without an increased air supply it will be quite impossible for him to maintain this percentage of CO_2 in his alveoli, since during work the percentage in the inspired air itself is 3, and he will suffer from severe panting. The diver must have twice as much air at 33 ft. to be as comfortable as at the surface, and at whatever depth he may be, his minimum air supply must be increased in the same proportion as the increase in absolute air pressure, or the volume of air supplied, measured at the pressure he is under must never be less than the volume he requires at the surface.

By regulating the air supply in this way two experienced divers were as free from respiratory distress at 210 ft., the greatest depth hitherto recorded, as when they were just below the surface. They could also reach this depth easily within two minutes, which showed the fallacy in the time-worn tradition that a diver should always descend slowly.

Not only is a diver's efficiency and compressure he is under, must never be less than fort promoted by the preventing of excessive carbon dioxide pressure, but a serious danger is obviated. It not infrequently happens that a diver becomes stupefied or unconscious from the effects of carbon dioxide, and the consequences may easily be fatal, as it is very dangerous to draw a man up rapidly from a great depth, and also dangerous to leave an unconscious man at the bottom.

In caisson and tunnels, as with individual divers, it also is necessary to insure sufficient ventilation or constant replacement of air to guard against ill effects from CO_2. To make these effects practically inappreciable it would be necessary to keep the pressure of CO_2 from ever rising above 1 per cent. of an atmosphere. When there is no other source of CO_2 besides the persons present, a minimum ventilation of 300 cu. ft. per man per hour, the volume measured at the working pressure, would suffice if the air were properly distributed. If this pressure were 30 pounds, gage, this would correspond to 900 cu. ft. of free air.

The possibility has to be borne in mind, however, of other sources of CO_2, besides other air impurities. If candles are used, or if there is blasting, or if decomposition processes are occurring in the mud, there may be present not only more CO_2, but also carbon monoxide, sulphureted hydrogen or other poisonous gases. Compressed air costs money, and it is therefore important to avoid all unnecessary sources of air impurity, so as to render excessive ventilation unnecessary. For obvious reasons the air ought also to be properly cooled before it is delivered.

CAISSON DISEASE.

Deep water divers are liable to sudden attacks of illness after reaching the surface. Sometimes death occurs, but paralysis, particularly of the legs or bladder, is more common. This paralysis often passes off after a time, more or less completely, but it may be permanent or may lead to a lingering fatal illness.

Among workers in caissons and subaqueous tunnels at high pressures similar cases of death or paralysis, or attacks of syncope, sometimes occur. Shortly after coming out of the air-lock. The most common symptom is, however, an attack of pain in a limb or sometimes elsewhere in the body, these pains being known among the men as "bends" or "scrims." They fortunately pass off soon and usually occur within an hour of leaving the air lock. The following is now accepted as an explanation:

When a gas is brought into contact with a liquid the latter takes up the gas in simple solution apart from any chemical combination, until a state of saturation is reached. The amount thus taken up depends upon the "coefficient of solubility" of the gas in the liquid and the temperature of the liquid, and varies directly with the pressure of the gas, in accordance with what is known as Dalton's Law. The blood passing through the lungs is practically in contact with the air breathed, and therefore takes up, when a man or animal is in compressed air, an increased proportion of nitrogen and oxygen in simple solution.

The increased proportion of oxygen so taken up only adds slightly to the total oxygen in arterial blood, since far more is normally taken up in loose chemical combination with the haemoglobin; and in any case nearly all the free (i. e., uncombined) oxygen of the blood disappears when the latter reaches the tissues. Carbonic acid is of course also present in the lung air to the extent of about 5.6 per cent. at ordinary pressure; but the compressed air makes no difference as regards the solution of CO_2 in the blood, since, unless the air breathed is very foul, the pressure of the CO_2 in the lung air is kept constant by the breathing, whatever the total atmospheric pressure may be.

The increased proportion of nitrogen taken up by the blood in compressed air passes to the various semi-liquid tissues, which gradually also become saturated, since nitrogen, unlike oxygen, does not disappear by entering into chemical combination. The whole body thus gradually becomes saturated with nitrogen at the pressure (79 per cent. of the total atmospheric pressure) which this gas exerts in the compressed air.

If the excess of air-pressure is now rapidly removed, as occurs when a worker in a caisson passes rapidly through the air-lock, it is clear that the blood and tissues will for a time be in a condition of super-saturation for the diminished pressure. In consequence of this the nitrogen will tend to liberate itself within the body in the form of bubbles, Just as CO_2 is liberated in bubbles when the cork of a bottle of soda water is removed. When a liquid is saturated by the contact with a gas the pressure exerted by the gas in solution is the same as that of the gas in contact with it. The gas in solution will tend to liberate itself in the form of bubbles if its pressure in the liquid exceeds the total external pressure. Thus, if the blood and tissues be saturated with air at 4 atmospheres pressure the nitrogen in solution will tend to liberate itself in bubbles as soon as the external pressure falls below 79 per cent. of 4 atmospheres, i. e., below 3.16 atmospheres. It does not follow, however, that any actual, or, at any rate, any rapid, formation of bubbles will occur, particularly in the case of an albuminous liquid like blood; and the lowest pressure by rapid decompression from which a fatal accident has occurred in a caisson worker is, so far as Dr. Haldane has been able to ascertain, 23 lb., gage, or 2.6 atmospheres of absolute pressure, corresponding to 53 ft. of sea-water. The occurrence of symptoms of any kind is very seldom observed with pressures of less than 2.3 atmospheres, or 19 lb. gage.

Paul Bert proved by numerous experiments on animals that sudden decompression from considerable pressures commonly causes death with symptoms of asphyxia, or else paralysis. The higher the pressure, and the longer, within certain limits, the exposure to it, the more absolute the certainty of death becomes. On post-mortem examination of the bodies of the animals he found the veins in various parts of the body full of bubbles consisting almost entirely of nitrogen; and in the cases with symptoms of asphyxia the right side of the heart was full of froth, which had completely blocked the circulation.

The symptoms of paralysis were evidently due to partial or complete blocking of vessels supplying the spinal cord or brain; and in animals which had survived the paralytic attack for a few days, softening and the usual degenerative changes were found in the spinal cord at the places where the block had occurred.

Paul Bert pointed out, and partly proved by experiments on animals, that in order to avoid compressed-air illness, slow decompression is necessary. He did not, however, show how slow the decompression required to be in order to secure safety, nor has human experience solved this problem. When the excess of pressure has exceeded about 1½ atmospheres, or 22 lb., the rates of decompression hitherto employed have proved more or less unsafe if the exposure has been long continued, and the higher the pressure the greater the danger with a given period of exposure. Heller, Mager and von Schrötter have laid down a rule that for each atmosphere of excess pressure an allowance should be made of 20 minutes for each atmosphere of decompression, and that the decompression should be at a uniform rate. The rule is doubtless a great advance in some respects on what has been the practice hitherto, but the calculation on which it is based is unsound. There is no real evidence that it would afford safety for pressure of even 30 lb., while for pressures below 20 lb. a much faster rate of decompression is well known to be practically safe.

From the existing evidence as to the mode of action of the lungs it seems certain that, whatever the pressure of nitrogen in the air breathed may be, the arterialized blood leaving the lungs will be practically saturated to the same pressure. On exposure to compressed air the unsaturated venous blood will become saturated in passing through the lungs, and on return to a lower air pressure the supersaturated venous blood will become de-saturated. On exposure to a high air pressure saturated arterial blood will be flowing from the lungs toward all parts of the body. But these parts are just as capable of taking up an excess of dissolved nitrogen as the blood is. Hence during its passage through the body-tissues the blood will lose most of its nitrogen to the tissues, and the venous blood returning to the lungs will contain very little of the excess of nitrogen with which it started. In the lungs, however, it will be charged up again, though the amount which it gains there will, of course, not be quite so great as at the previous round of the circulation. At the next round the amount carried away will be still less, and so on. The process of de-saturation on return to a lower pressure must take place in a similar way, provided there has been no formation of bubbles, or anything else to complicate the conditions.

The time actually required to produce any given degree of saturation or de-saturation in any part of the body remains, however, quite uncertain so far. Some parts of the body have a very rapid circulation, and will therefore saturate and de-saturate quickly. Other parts, however, have a small circulation of blood in proportion to their mass, and must therefore saturate and de-saturate slowly. We at first over-estimated the rate at which saturation and de-saturation occur, partly due to ignorance of the fact that fat dissolves about six times as much nitrogen as blood. The fat scattered throughout the body thus acts as a reservoir for nitrogen; and this probably about doubles the time needed for saturation to occur.

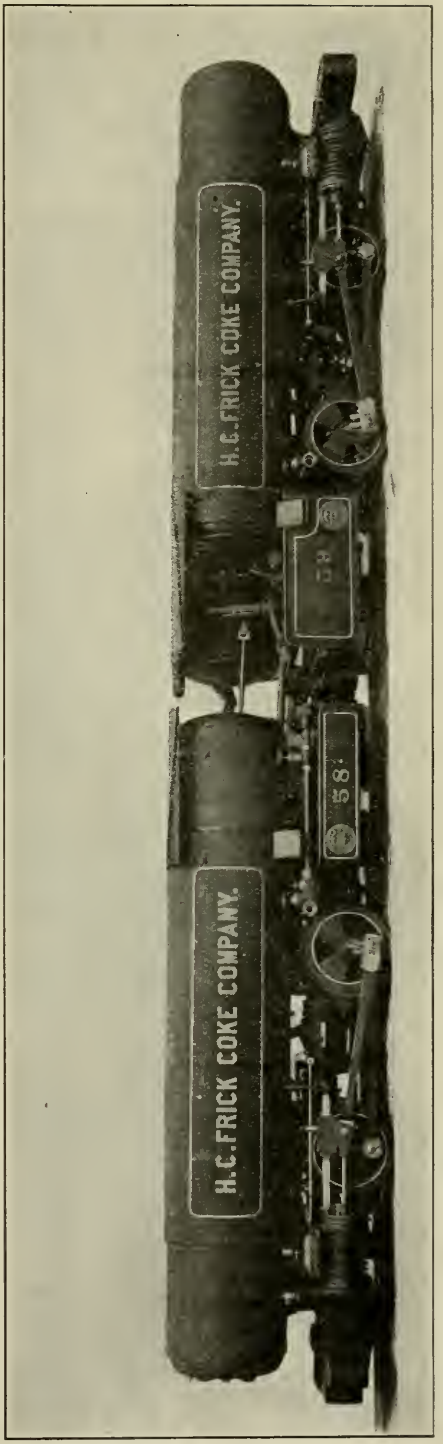
In goats some parts of the body giving rise to symptoms on decompression are not more than half-saturated in 45 minutes, and will de-saturate with corresponding slowness. The rate of circulation in man is only about two-thirds as fast as in goats. Hence, in man, there will be some parts of the body which only half saturate in 1¼ hours. Previous investigators have inferred that saturation and de-saturation occur far more rapidly than this; but the above conclusions are in accord with practical experience in caisson work. Mr. E. W. Moir, M. Inst. C. E. (of Messrs. J. Pearson & Son, Ltd.), who has given great attention to the whole subject and introduced important measures for the safety of workers in compressed air, states that even after three hours' exposure to compressed air the cases of illness are less frequent than with longer exposure; and similar evidence has been brought forward by Mr. G. W. M. Boycott. This can be well understood if the rate of saturation is so slow.

(*Continued on Page* 5123.)

TANDEM COMPRESSED AIR LOCOMOTIVES

The Baldwin Locomotive Works have recently built eight compressed air locomotives for the H. C. Frick Coke Company, a pair of them being shown in the half tone. These engines are alike except that six of them have a track gage of 3 ft 6 inches and the other pair 3 feet 4 inches. They are for a gaseous mine where the employment of electricity would be dangerous, the operating conditions requiring the hauling of heavy loads up grades as steep of 5 per cent. and around curves of 180 feet radius. The restricted clearance limits made it practically impossible to design a single locomotive meeting the conditions, so they were arranged to be operated in tandem as here shown.

The locomotives are coupled back to back, one operator controlling the two units by a single throttle lever, reverse lever, brake valve, etc., the locomotives also being charged simultamously by means of a flevible connection between the air tanks. This flexible connection is closed when the locomo-



TANDEM COMPRESSED AIR LOCOMOTIVES FOR COAL MINES.

tives are in operation, but the auxiliary, working pressure tanks are then in communication through a rubber hose, so that the cylinder pressures on the two units are equalized. This pressure is maintained by the reducing valves at 150 lbs., the initial pressure in the storage tanks being 800 lbs.

Each locomotive is provided with two air tanks, one of which is about 30 inches shorter than the other to allow room for the operator. They are built of steel plates ⅞ inch thick, being 31 ¾ inches in diameter, and the longest 14 feet 9¼ inches long. The circumferential seams are triple riveted and welded, and are further reenforced by an inside liner secured to the shell by eight rows of rivets.

The details of construction, as far as frames, running gear and valve gear are concerned, present many features similar to those of the steam locomotive practice. The frames are of cast steel, of the usual bar form in the middle and narrowed down to a slab section at each end. The air tanks are supported on cast steel saddles, one of which is bolted between the slab frames at each end of the locomotive. The cylinders, 8 by 12 inch, are cast separately and are placed outside the frames. The driving wheels are 4 feet 6 inches diameter, the combined weight of the two locomotives is 46,400 pounds, and as the normal traction force is 8,160 pounds, a liberal factor of adhesion is assured. The equipment throughout is most complete for a locomotive of this type, and special attention has been given to making the coupling devices simple and positive in action so that the locomotives can be readily operated in tandem.

SCIENCE AND SUGAR

Gallileo discovered the hydrostatic balance in 1586, but apparently did not utilize the idea, although he invented the thermometer. It remained for the pupil, Torricelli, to invent the barometer which measures the vertical weight of the atmospheric air surrounding the earth and as this could be done with the heaviest liquid we know of, mercury, or with water, the tubes, now known as barometrical, were then known as Torricellian tubes. When Howard invented the vacuum pan in 1819 he utilized the 17th century idea as to a vacuum that with the removal from the surface of a liquid mass of the weight of the atmosphere in whole or in part, the boiling point of the liquid became reduced. To operate the vacuum pan the air pump was utilized for the double purpose of removing the air pressure and also for condensing the vapor of evaporation. This method of condensation was successfully used by Howard and his successors, until about 1850, when the so-called dry vacuum, in contradistinction to the older method, then called wet vacuum, came into use. The dry vacuum method necessitated a condenser sufficiently high to balance the atmosphere, utilizing Gallileo's hydrostatic balance and an outlet sufficiently large to discharge the water of condensation into a foot tub, thus utilizing Torricelli's barometrical tube in which the height of the water counterbalanced the degree of vacuum obtained in the boiling pans. In 1870 there was only one vacuum pan in Louisiana that had an elevated condenser and Torricellian or barometrical tubing outlet, or that was built, as is commonly said, on the dry vacuum plan. That pan was in the sugar refinery of Paul Cook, one of our early sugar refiners, whose descendants are among our prominent sugar people of the present day. The next dry vacuum apparatus was erected at that time on Belair plantation, below the city of New Orleans, by Mr. John Dymond. Gradually the dry vacuum method of boiling came into general use and of course such use was improved with the development of sugar refining and with the more advanced methods of sugar manufacture.—*Louisiana Planter.*

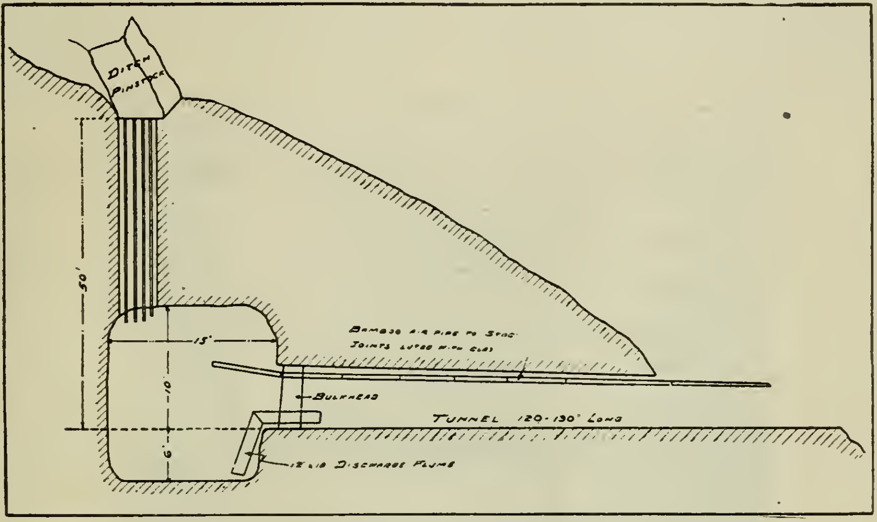
AN OLD SPANISH AIR COMPRESSOR OR BLOWER

By C. F. Spalding.

I stumbled onto the remains of an old smelter a few miles from the trail leading into Tegucigalpa and about four to five days' ride from San Pedro Sula. The place was overgrown with jungle and the natives themselves knew nothing about the plant or when it was abandoned. I found it by following an old ditch line about three-quarters of a mile long, while looking for placer workings.

The dump showed about 100 tons of slag (copper) and some raw copper ore around the foundation of the stack; but what interested me most was the means they evidently used to make the air blast. Back of the stack a hundred odd feet was a small tunnel just large enough to crawl into comfortably. I went into it expecting to see the place from which they obtained their ore, and instead found the compressor plant.

The tunnel was driven into the side hill about 120 to 130 ft. At the inner end it was enlarged to a room about 10 to 15 ft. high 15 ft. long and 6 to 8 ft. wide. The room floor was several feet below the level of the tunnel floor, approximately 6 to 7 ft., but being partially filled with debris, sticks, leaves, etc. (packed in by tigers for their lair), it was hard to find the real bottom.



OLD SPANISH HYDRAULIC AIR COMPRESSOR.

At the inner end of the room was a vertical upraise about 3ft. in diameter through to the surface. This hole was filled with bamboo pipes 6 to 10 ins. in diameter (14 pipes in all) set in clay, filling the upraise solid. This got me interested and I started to investigate. At the top of the upraise and end of the ditch was a crude penstock built with brick, showing where the water was discharged from the ditch onto the top of the bamboo pipes and flowed down the pipes. Leading into the tunnel, along the roof, was a bamboo pipe 4 to 5 ins. in diameter. This was badly rotted and fell apart on touching.

The pipes in the upraise were in a fair state of preservation. The inner end of the tunnel showed traces of being at one time bulkheaded. Running through the bulkhead was a wooden flume made from a native wood that is practically indestructible.

This flume was about 12 to 18 ins. inside dimensions and extended through the bulkhead, making a turn to the bottom of the room. Evidently this apparatus was used somewhat as follows; the water rushing down the tubes from the pen-stock would suck in air; this would be liberated in the inner room and taken out for blast purposes through the upper bamboo pipe in the tunnel, the water being discharged through the wooden flume at the bottom of the bulkhead.

The bottom of the flume being 5 to 6 ft. below the outlet would give an air pressure of 2½ to 3 lbs. I could not figure out any other use for the layout than that of compressing air, and must say that it was sometime before it dawned on me what I was seeing. I could hardly believe that those old fellows knew enough to figure out a scheme like that.

The place had been abandoned 150 years or more, as there were trees of that age growing on the dump ditch line.—*Mining World.*

The atmospheric pressure for altitudes not excessive may be approximated by subtracting 1 inch from the barometer reading at sea level for each thousand feet of elevation. Thus at 6,000 feet this rule gives 24 inches, which is only between 0.1 and 0.2 inch too high, or much closer than any engineer reads his gage in practice.

KILLING WEEDS BY SPRAYING CHEMICALS

A company has been formed and has commenced operations whose purpose is the destroying of weeds along railroad tracks and elsewhere. The apparatus employed sprays the weeds with a chemical preparation, the theory being that the solution is breathed in by the plants, becomes mixed with the sap, and in this way kills the roots. The vegetation above ground is killed in 12 or 14 hours and it is said the roots will not sprout again. The attitude of the company seems to indicate confidence. It does not sell the apparatus nor the chemical solution, but is prepared to make contracts with railroads to sprinkle the roadbed for so much a mile under guarantee that if the weeds are not killed no charge will be made.

For steam roads the outfit consists of a 40 ft. flat car of 100,000 lbs. capacity with a 4,000 gallon tank on each end, and in the middle of the car there is a cab for the storage of the necessary chemicals and to cover steam heating and other apparatus. To effect a chemical mixture of the ingredients the water must be heated to the boiling point, which when convenient may be done by taking steam from the locomotive. The car is equipped with air compressors for applying pressure to the solution tanks so that the spraying apparatus will operate at constant pressure, regardless of the head of the water in the tank. The spraying apparatus consists of six nozzles arranged in a line crosswise under the car and near one end, with pipe connections to both tanks. The flow is automatically regulated according to the speed of the car, delivering about 500 gals. per mile, and effective work is done up to a speed of 10 miles per hour.

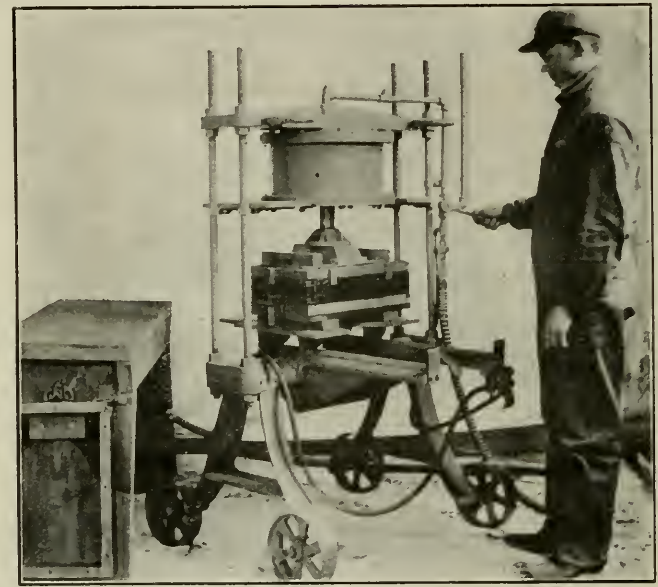


FIG. 1—RAMMING DRAG WHEN MATCH BOARD OR SAND MATCH IS USED.

"THE TWENTIETH CENTURY" MOLDING MACHINE

The half-tones show a portable pneumatic molding machine built by the J. F. Webb Manufacturing Company, Davenport, Iowa. The machine is specially adopted for general jobbing and for railroad repair work, using ordinary patterns without special preparation. It is a positive pressure machine, using air of the ordinary shop pressure. There is a light, stiff cast iron frame with legs of suitable height which have bosses for wheels which may be used or not as desired. From the frame or bed rise four rods which carry the air cylinder and pressure mechanism. Air is admitted to the cylinder by a special valve which gradually applies the pressure to the mold, the travel being adjustable to secure absolutely uniform ramming. As was said, ordinary patterns, such as are used in hand molding, can be employed on this machine. A stripping plate can also be used to advantage. The air cylinder is 13 inches diameter, giving, with 100 pounds air, a total pressure of nearly 7 tons.

Fig. 1 shows the ramming of the drag when a sand match is used. There is a small traveler which is a part of the machine and is moved easily in or out on roller bearings. The drag part of the flask is put on and a sand frame 1 inch deep is placed on the drag to hold the extra sand required to fill the mold. The flask is filled with sand, the pressure head is placed on top and the traveler with the mold is pushed under the pressure cylinder, the air is turned on and the mold is rammed by the descent of the piston. The mold is then run out from under the cylinder, the pressure head is removed and the extra sand struck off; the bottom board is then put on and the flask rolled over, when the cope is rammed in the same way as the drag. The hardness of the sand can be regulated by raising or lowering the air cylinder by the nuts on the side rods.

Fig. 2 shows the machine ramming both cope and drag at one operation. This can be done when the patterns are mounted on a plate or board. The machine is made in two sizes, 30 and 36 inch.

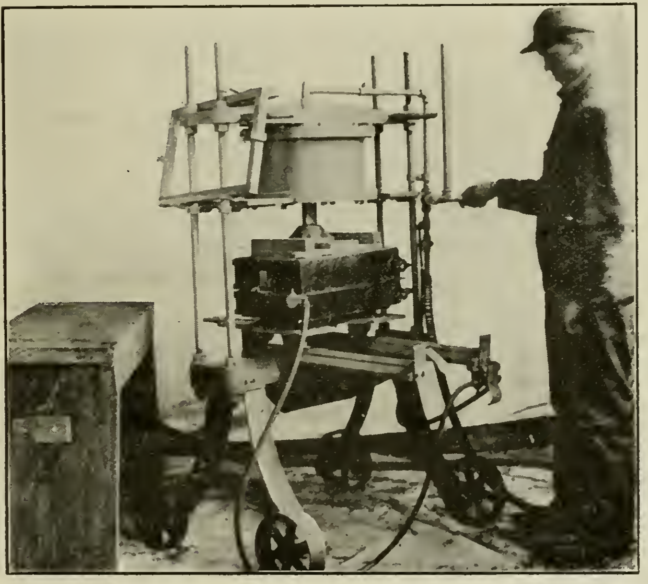


FIG. II—RAMMING BOTH COPE AND DRAG IN ONE OPERATION, THE PATTERNS BEING MOUNTED ON A PLATE.

WHY A COMPRESSOR CYLINDER MUST BE WATER JACKETED

By Lucius I. Wightman.

When a volume of air or gas is compressed from a lower to a higher pressure, all the work done upon that volume is converted into heat. This is the result of an increased activity imparted by the compression to the molecules composing the air or gas, but the process by which this activity, appearing as sensible heat, is produced need not enter into this discussion.

In the modern compressor, water jackets are provided surrounding the compressor cylinder for the purpose of carrying away, so far as may be, this heat of compression. In other words, power is expended in producing heat, which is then carried away by the cooling water without any useful effect. The compression process produces heat and pressure; the jackets carry away the heat, leaving only the pressure to show for the energy expended. Why not retain both the heat and the pressure, thus securing more nearly the full equivalent of the power used? The object of this paper is to explain this apparent anomaly.

The compression of air or gas must raise its temperature, whether the process be slow or fast. But raising the temperature of air produces one of two results. If the air volume is confined in a limited space, an increased temperature results in an increased pressure, due to the expansion of the air. If the volume is not confined, the increased temperature produces an increased volume, again due to expansion.

Assume that we have a compressing cylinder with a cross-section of 1 square foot and a piston travel of 6 feet, thus giving a cylinder volume of 6 cubic feet. Let this cylinder be filled with air at sea-level, atmospheric pressure 14.7 pounds and at 60 degrees Fahrenheit. If the piston is now advanced for one-half its stroke, or 3 feet, this volume will be compressed to one-half its former volume, or we will have two volumes in the space of one, giving, at first glance, a pressure twice as great, or 29.4 pounds. If we continue to advance the piston until it has traveled 5 feet, we will have crowded our original volume of 6 cubic feet into a space of 1 cubic foot, and we should have a pressure of six atmospheres, or 73.5 pounds, gage.

As a matter of fact, in the latter case we will have a higher pressure than 73.5 pounds, the excess being due to the heat produced in the air in compressing it from one atmosphere to six. Just what this final pressure would be cannot be stated exactly. If our cylinder and piston were so made that not a particle of the heat could escape from the air volume, its temperature at a pressure of six atmospheres would be a little over 419 degrees Fahrenheit. But as some of the heat is bound to escape, this temperature is never fully attained. However, enough heat remains to increase the pressure, at the end of six compressions, to more than six atmospheres.

It would thus seem that we had expended more power than necessary, if six atmospheres was the pressure we set out to attain. The combined effect of the heating and compression produced a pressure of six atmospheres before the piston had traveled five-sixths of its stroke, and if the discharge valves were arranged to open at just that point, we could have saved the power required to produce this excess pressure.

The difficulty is that the pressure, which is the combined result of compression and heating, is not a stable pressure. The heated air, discharged at six atmospheres, rapidly cools or loses its heat by conduction and radiation. Now, the cooling of a volume of air in a limited space reduces its pressure, just as heating it increases its pressure. The heated air at six atmospheres rapidly cools and its pressure drops, so that while we have compressed to six atmospheres in the cylinder, we actually have a pressure less than this in the pipe line available for work.

To produce a stable effective pressure of six atmospheres in the pipe lines, we must carry the cylinder pressure higher than six atmospheres, so that after the compressed air has cooled to the temperature of its surroundings, it will have the final pressure we set out to attain at our working tool. The difference between the six atmospheres on the line and the higher pressure in the cylinder represents an expenditure of power without useful effect, due to the heat of compression which was allowed to remain in the air during compression.

RESULT WHEN AIR IS COOLED.

Now what would have been the result if we had arranged to cool the air during compression? Suppose we had made the walls and heads of the cylinder double, circulating cold water in this space, moving the piston forward very slowly and giving the water time to absorb and carry away all the heat of compression as fast as it is produced. There would be no excess pressure due to heating; the reduction of the volume from 6 cubic feet to 1 would produce exactly six atmospheres of pressure, and the air at this pressure would be in a stable condition. Thus the use of the water in this case would actually have saved us the power otherwise required to produce the higher ineffective and useless pressure.

But, as a matter of fact, the condition just outlined is impossible of attainment in actual practice. Every-day results are a compromise between the two systems of compression which have been discussed.

A compressor cannot, in practice, be run so slowly as to permit all the heat to be absorbed and carried away by the jacket water. Temperature increases with the pressure, while the advancing piston steadily reduces the cooling surface of the cylinder walls with which the air is in contact. Near the end of the stroke, when pressure and temperatures are highest, the greater part of the cooling surface exposed is the cylinder-head, thus explaining the importance of head jacketing. Heat is conducted from one particle of air to another very slowly, so that after all, the interior of the air volume is not cooled by the jacket, but only that external film in contact with the cool cylinder walls.

All things considered, therefore, water jacketing a compressor cylinder results in only a part of the saving of power which in theory it promises. Some beneficial effect along this line it certainly has, particularly in long stroke, slow-speed machines. But the full benefit of cooling during the compression can be secured only by other means—by the breaking up of the compression process into several intervals, between which the air is cooled by external means.

Cylinder jacketing is nevertheless essential in the modern air or gas compressor. Aside from the economical consideration just explained, it has other important effects on the proper operation, and indeed on the economy of the compressor.

THE EFFECT UPON LUBRICATION

Not the least important of these is its effect upon the lubrication. The compression of air from sea-level pressure and a temperature of 60 degrees Fahrenheit to six atmospheres, or 73.5 pounds, produces, unless some cooling is provided, a temperature of about 419 degrees Fahrenheit, as already stated. Such a temperature as this is destructive of all ordinary lubricants and packings, and the result would be a rapid wear of the piston, cylinder and valves, with inevitable leakage, loss of capacity, increased friction and excess power consumption. The water jacket keeps these parts reasonably cool, resulting in free lubrication, little wear, easy running and sustained efficiency.

An attempt to run continuously without jackets would heat the cylinder, valves, rods and other parts to such a degree that dangerous expansion stresses might be produced, resulting in distortion, added friction and possible breakage. The alternate expansion and contraction between the extreme temperatures of operation and shut-down would make it practically impossible to keep tight joints.

It is just as essential that air should be admitted cool to the cylinder, as that it shall be kept cool during compression. For cool air is dense air, and the cooler the air admitted, the greater in proportion the volume of compressed air delivered. The heating of cylinder walls, piston, rod, valves and ports means that the air entering the cylinder will be heated by them—first, while entering through the valves and ports, and second, by contact with the interior of the cylinder. This means lowered efficiency of the compressor and reduced capacity; and, since jacketing at best is only partially successful, this fact suggests the advantage of those constructions admitting air in a large body through one or a few large openings, rather than through a large number of small valves.—*Power and the Engineer.*

FOR SYSTEMATIC INSPECTION OF THE AIR COMPRESSORS

In the Report of the Committee on Maintenance and Inspection of Electrical Equipments, to the American Street & Interurban Railway Engineering Association, Atlantic City, N. J., Oct. 12-16, 1908, the following related to air compressors:

Your committee thought that, owing to the increased use of compressed air on city and interurban cars, it would be well for it to consider the matter of maintenance of air compressors. In order to get the ideas of the different members of the association on this subject, several questions were asked. To the question, "How often do you overhaul air compressors?" the answers shown in Table I were received:

TABLE I. OVERHAULING OF AIR COMPRESSORS

No. Roads	Compressors	Overhauling Period
1	7	150,000 miles
1	480	60,000 "
1	18	25,000 "
1	40	5,000 "
1	600	18 months
16	970	20 "
11	398	6 "
3	145	3 "
6	289	when needed
18	125	non-committal.

The duties of an air compressor on city and interurban cars vary greatly. For instance, a car may be equipped with air doors, electro-pneumatic control and air brakes. The average distance between stops for a car of this character in city service may be every 1,500 ft. A compressor under these conditions would necessarily have to be overhauled much more often than one that made stops two or three miles apart, had no air doors or electro-pneumatic control. It also is evident that the first class of service would require a compressor of larger capacity than service of the second class. As a general proposition no air compressor should be required to operate more than 33 1-3 per cent. of the time.

The committee believes that with a compressor designed to have sufficent capacity for the service it is to perform, an overhauling for service of the first class should be made every 60,000 miles. A compressor for the second class should be overhauled every 120,000 miles. The overhauling of a compressor should be thorough, and should consist of the following:

Compressor should be taken from under the car and placed on a bench where armature should be removed, oil drained from crank case and all bearings outside of crank case, and then the bearings should be thoroughly washed with gasoline.

If wear is excessive, the crank shaft and connecting rods should have the slack taken up or the bearings should be re-babbitted or re-lined with bronz bearings, as the case may be.

The head should be taken from the compressor, ports scraped out, hair removed from hair strainer and washed in gasoline; and valve and valve seats should be reground.

Armature should be taken to the armature room, blown out, cleaned and break-down test applied. Also the commutator should be trued up. Mica retaining rings should be painted with insulating paint. Armature painted with a coat of oil-proof insulating-paint.

Brushholders should be cleaned in gasoline and overhauled, replacing worn tips and shunts that have broken strands.

Field coils should be taken out and insulation carefully looked over, and replaced if necessary.

The inside of the motor shell should be carefully cleaned with gasoline to get oil and dirt out of shell.

The committee recommends the impregnation of pump field coils as tending to cut out all field troubles and greatly prolong the life of the fields.

The piston should be removed from the pump, and the rings should be removed from the groove and carefully cleaned; also, the groove should be carefully scraped out.

Springs from piston rings should be tested to make sure that they have not lost their tension.

If, when the pump is re-assembled and started to work under pressure for five minutes, it be then disconnected and allowed to run free, and oil is discharged from the outlet, it is an indication that the rings are not tight enough in the cylinder, and springs of greater tension should be put in the rings.

The insulators placed between compressors and air piping on car should be taken from the car and cleaned and given a break-down test of 1,000 volts.

The oil which was removed from the compressor when it came in should be run through a filter and returned to the compressor, enough oil being added to take the place of dirt, etc., which it contained when removed. In this connection care should be taken to use an oil which does not contain asphalt or which will not carbonize when the pump is given hard usage.

INSPECTION OF AIR COMPRESSORS.

The frequency of inspection of air compressors should be determined entirely by the scrivce to which they are subjected. In answer to the question, "How often do you inspect air compressors?" the following replies were received:

13 per cent. inspect daily.
6 per cent. inspect twice a week.
47 per cent. inspect weekly.
1¾ per cent. inspect every two weeks.
½ per cent. inspect monthly.
25 per cent. inspect from 400 to 600 miles.
1 per cent. inspect 1,200 miles.
5¾ per cent. inspect when cars are inspected.

Your committee recommends that air compressors subjected to the severe service described above under Air Compressor Maintenance should be inspected as follows (the inspection period to be based on 600 miles):

Oil plug should be removed and oil added each inspection day to replace that lost in service.

Remove carbon brushes and inspect each inspection day.

Inspect brush-holder tension each inspection day.

Wipe off brush-holder each inspection day.

End of commutator should be wipedoff each inspection day.

Hair should be taken out of hair strainer, and strainer washed in gasoline every thirtieth inspection day.

Valves should be taken out and cleaned in gasoline each thirtieth inspection day.

Exterior of pump should be wiped each inspection day.

Compressors should be thoroughly blown out with compressed air each tenth inspection day.

Cars of the second class of service should be inspected as above, only the period of inspection should be 1,200 miles.

The committee recommends that the following tests of compressor be made after the above inspection is completed: With all air reservoirs empty and brake valve on release position, start air compressor and note length of time taken in pumping up, and pressure at cutting out point. The inspector will learn to tell when a compressor is not working properly by this method. A test for leakage should then be made, leaving apparatus in same condition as above, and noting number of pounds drop in one minute; the inspector will soon become educated to detect leaks in this manner.

NOTES ON MACHINE ROCK DRILLING

By George C. McFarlane.

For all ordinary mining work, particularly sinking and drifting in hard rock, a 3, or 3¼-in. machine, of any standard make, will give good satisfaction. Among the factors which make for fast drilling and rapid driving are good strong machines, kept in first-class repair; good air, that is, air free from entrained moisture and under a pressure of 80 lbs. or 100 lbs., or even more; sharp, square-bitted steel of the smallest possible gauge; using as few flat, dry holes as possible; and arranging the work so that the holes have good square starts. In all hard-rock mines, unless ventilation is extremely poor, it pays to drill small-gauged holes, heavily burdened, and spring them a couple of times, so that they will take big charges of explosive.

Wherever a number of machines are used, it pays to keep a good man to look after the machine repairing and attend to extending the pipe lines, and to see they don't leak. The machines should be taken apart, cleaned, and broken or worn parts replaced at least every two weeks; the brass rotating nut in the piston, particularly, should be renewed at the slightest sign of wear, as in hard, slippy ground it is important that the drill is twisted sufficiently. It also pays to frequently renew the chuck bushing, as with a worn chuck bushing it is impossible to chuck a drill straight, and the starter wobbles all over the face in starting a hole.

HIGHER AIR PRESSURES.

The increasing tendency to use higher air pressures for rock drilling is a very good one, and I have found it advantageous to use pressures even up to 140 lbs. At this latter pressure it is found that machines use very little more free air than at 100 lbs.

In places where only 70 or 80 pounds of air is carried at the compressor, the pressure at the machines is very weak, especially when two or three machines on one small pipe line are started up together. In this case the machine drags the steel back and forth and wears the gauge of the steel just as much as hard, solid blows.

One of the most exasperating features of drilling hard rock is the frequent "fituring" of the holes, caused by the steel glancing and deflecting when the hole encounters heads and slips at acute angles. When a hole fitures before it is half way down, it is impossible to finish it, and a new hole should be started at once; however, most runners will twist and pound the chuck for an hour or so before they give a hole up. The best way to guard against fituring is to have the steel gauged small, and instead of dropping the gauge 3-16 in. per ft., shade the gauge 1-8 in. or less. For 8-ft. holes, use a 2-in. starter and finish the hole 1 3-8 in. or 1 1-2 in., and use very long bits on the starters and seconds, the bits being made of cruciform steel only a trifle smaller than the gauge. These long bits tend to hold the hole pretty straight on the start. The long drills of the set should be of light steel and fitted with shorter bits, so that the drill can weave around a little to follow the hole if it runs a little crooked. The bits should be square and the corners sharp. When starters with big wings and with the corners dubbed back are used to begin a hole, the hole will rifle more or less if the rotating mechanism of the machine is the least worn; then, as the hole goes down, the steel will be twisted with difficulty and easily sheared off by a slip.

Another advantage of using small starters and using very little drop to the gauge is, that the hole drills much faster; a 2-in. starter will drill 1 ft. in 5 min., where a 2 5-8-in. starter would require about 7 min.; from this it follows that large bits wear their gauge faster than small bits.

DRILLING SMALLER HOLES.

A couple of years ago, in the heavy rock cuts along the line of the C. P. R. R. and G. T. P. R. R., in New Ontario, the deep holes in the hard granite and trap would be started with 3 1-2-in. and 4-in. starters. Now, many of the contractors are putting down 25-ft. and 30-ft. holes and starting them with 2 1-2-in. bits, and the drills are turning out 40 per cent. more footage.

In the Dutton tunnel, near the Winnipeg river crossing of the Grand Trunk Pacific, the semi-circular heading, 9 ft. high and 16 ft. wide, was driven through extremely hard granite with two Electric Air drills. A round of 28 holes, each about 10 ft. deep, were drilled. These holes were started with a 2-in. drill and finished with a single-bitted 1-in. steel, the bit being just a shade larger than the steel. These small holes drilled very fast, an average footage of 45 ft. being turned out by each machine in a shift. One of the machines made 97 ft. in a 10-hour shift. After the round of holes was drilled, and the machines rigged down, all the holes were sprung twice, an average of 3 sticks being used for the first spring, and 6 sticks for the second spring, the 6 in-cut holes being sprung the heaviest.

SPRINGING THE HOLES.

It took 4 men 3 hours to spring the holes twice, after which they were allowed to cool 2 hours before tamping in the blasting charge. Thus the springing required just about half a shift. When the holes were sprung they broke clean to bottom, and the roof and sides were left in good shape, not requiring any more scaling than was necessary before using the spring method. When drilling the small holes, the two machines would put in a round of 10-ft. holes in three shifts, each round advancing the heading 9.2 ft. On the start, before the foreman tried springing the holes, it was necessary to drill very large holes in order to get enough dynamite in the bottom of the hole to break the ground, the holes being started with a 2 3-4-in. bit, and finished at a depth of 9 ft. with a 1 15-16-in. bit. It required 5 shifts for the machines to put in a round, and the average break was 7.4 ft. per round. This gives an idea of the economies that can be effected by springing holes where the rock is very hard. Of course, the method would hardly be applicable to softer rock, as it would probably be cheaper to drill a larger hole than to spend time and explosive chambering out a small hole. This, however, is a matter of direct calculation from actual demonstration.

It is always good policy, when driving drifts and crosscuts in hard ground, to drill the full round before blasting. In some localities the machine men drill and blast the incut first, and then rig up and drill the squaring. When this is done, they always get poor starts for the squaring holes, as a slanting face is left when the cut holes kick out, and it takes as long to get a hole started, in hard rock, on a slanting face as it does to drill the entire hole after the start is made. For the same reason, I prefer a "V" in-cut to a "draw" or "side-cut," unless there is an exceptionally good floor or slip to break to. With a side or bottom in-cut, most of the holes have to be started on a bad slant, while with a "V" cut all the holes go in very nearly square with the face, and, by springing the cut holes twice, or even once, it is possible to get clean breaks every round.

The machine steel should invariably be made on the ground, as it can be made by any fairly good blacksmith for a great deal less money than the manufactured bits can be purchased for. For making machine bits, the common grades of bar and cruciform steel, costing from 7 cts. to 8 cts. a pound, is just as satisfactory as the high-grade brands of American and English tool steels, costing up to 20 cts. a pound. Every mine blacksmith has some particular fad about making or tempering drills. To handle the work to the best advantage, the blacksmith should be able to make good steel welds. Of course, it is possible to make a bit by upsetting the steel, but it can be made in half the time by welding on a short length of cruciform steel. While it is essential that a bit should be properly tempered, it is just as important that the bit be properly made and the steel worked properly every time the bit is sharpened. The wings of the bit should be equally proportioned, rather heavy, the corners should be square, and the shoulders slope back very gradually from the cutting edge. In making the bit, care must be taken not to chisel into the core of the bit in splitting, because, when the core is deeply chisel-marked, the corners will break off in tempering. In sharpening a dull bit, most of the work should be done with a cross-peined hand-hammer; with light, quick blows of the pein of the hammer, the metal is worked from the center outward to the corners and down to the cutting edges; and many times this hand-hammering will be all the sharpening that is necessary. Every second or third dressing the bit will have to be squared up with a dolly and side-flatter and gauged with a half-round swage.

Of the many different ways of tempering machine drills, I have found the following to give the most uniform results: After the bit is sharpened, it is heated up to a bright red heat; at this heat the surface will mottle with little blisters or blebs if the drill is pulled out of the fire. At this heat, or even hotter (as the exact degree of heat does not seem to be important), the drill is shoved about an inch into the water, swished around to keep the point sizzling in fresh water, and occasionally soused to gradually cool the bit back of the cutting edge. In about 20 seconds the bit can be dropped into the tub. This method of tempering makes only the cutting edge hard, and also seems to toughen the bit. Another method which gives good results but takes more time, is to let the bit get cold from the sharpening heat, then heat to a cherry red and plunge into the tub, take out, warm it over the forge, swab it with black oil, burn the oil off and again plunge in the tub. Ordinarily, blacksmiths throw the drills into the tub, right off the anvil. Generally they are not hot enough to take a hard temper, and they are heated so far back that when they do break off, about half the bit stays in the hole.

DAMP AIR.

In low altitudes, particularly on hot, muggy days, the air coming to the machines is often wet and gives a good deal of trouble by freezing up the exhaust ports and stopping the machine. In one mine where the air was continually freezing in the machines, I found the air as it came from the compressor was so hot that you could not hold your hand on the air receiver. I particularly remedied the trouble in this instance by covering the receiver with burlap and spraying it with water from a perforated pipe, which cooled the air enough to condense a considerable amount of the water, thereby trapping it in the receiver.—*Mining Science.*

TRAPPING RATS

Engineers and contractors sometimes find rats a nuisance, or worse, in their workings and have to take measures for their extermination. The following is a summary of a collection of articles written by the employees of the U. S. Public Health and Marine Hospital service engaged in rat catching at San Francisco. These men have demonstrated their knowledge of the subject by continuous large catches, and what is here detailed is the result of actual experience; it will be found to be highly interesting reading and the information conveyed is out of the usual run.

Rats are to be found where there is an abundant food supply, and the best places to trap them are slaughter houses, meat markets, chicken houses, and wherever garbage is accumulated. If a rat is deprived of this food supply it will be attracted by the bait and enter the trap.

When rats are plentiful the large 19 inch French wire cage trap has given very good results. It should be made of stiff, heavy wire and be well reinforced, as a large, strong rat will force his head between the wires of a weak trap and escape. The lever on the trap should be tested to see that it works properly. The trap should be placed on a hard surface with the rear end a little higher than the entrance so that the trap will close promptly. When setting the trap in an open place it should be fastened to a board on which about an inch of soft earth has been spread. Place the trap where rats usually go for food, or in a runway, and disturb the surroundings as little as possible. It is sometimes well to place the trap near dripping water, as the rats may go there to drink. If the trap is set in hay, straw or wood it should be covered (except the entrance) with the same material. When this is not possible, it should be covered with a piece of sacking, or placed in a dark corner or beneath the floors. When setting the traps in a sewer a dry place should be chosen.

The rat is more or less of an epicure, therefore the bait should be changed at frequent intervals. For bait the rat should be given food which it is not usual for him to obtain. In a meat market, for example, vegetables are the best bait, while in a location where vegetables are plentiful, fresh liver and fish heads or a little grain are best. The following may be suggested as good bait to be used: Fish, fish heads, raw meat, cheese, smoked fish, fresh liver, cooked corned beef, fried bacon, pine nuts, apples, carrots, and corn. When trapping in chicken yards a small chick or duckling is a remarkably good bait. When a large number of rats are caught in one trap, search for the female rat and leave her alive in the trap, as she may call in the young or the males. The bait should be fastened to the inner side of the top of the trap with a piece of fine wire, so that the first rat that goes in can not force the bait underneath the pan and thus prevent the entrance of other rats. A few grains of barley should be scattered near the entrance of the trap and a small piece of cheese or meat fastened to the pan with a bit of wire. It is often well to touch the pan with a feather which has been dipped in oil of anise or oil of rhodium. The trap should be smoked with a piece of burning newspaper to take away the smell of the human hands, or of rats which have been caught in the trap. Do not handle the trap after burning it out. When trapping in a neighborhood where rats are known to exist, the traps should not be moved for three or four days unless they have rats in them, as it is well for the rats to become accustomed to seeing the traps and thus careless about entering them. It is not wise to kill rats where they are caught, as the squealing may frighten away the other rats.

Snap or spring traps are best for use in houses and stores, with the exception of fish and meat markets. Snap traps are best for use in runways and on beams and shelves. It is sometimes well to disguise the trap by covering its floor with a little sawdust or dirt. The traps should first be tested to see that they work properly and that the staples are secure. New traps should be smoked or stained to render them of an inconspicuous color.

The bait should consist of some firm material, such as fried bacon or tough meat, and should be tied on so that the rat will be obliged to pull on it and thus spring the trap. The trap should be placed in a corner or close to the wall on a flat, hard surface in order that the rat cannot spring it with his tail or by walking on it.

In warehouses and granaries large numbers of rats may frequently be trapped by using a barrel or garbage can having a metal top which is carefully balanced. A large piece of strong cheese is placed in the middle of the cover and a plank laid from the floor to the edge of the barrel. The rat runs up the plank and on the smooth lid, which tips, precipitating the rat into the barrel.

DAMPNESS AND DYNAMITE

Dynamite should never be stored in tunnels nor in any place where dampness exists. Although a tunnel may seem dry, all rock-in-place contains from 3 to 8 per cent. of moisture, which is continually being brought to the wall-surface in underground workings by capillarity, where it is evaporated unless, for want of ventilation, the air is saturated. Thus the rock is continually contributing moisture, which is greedily absorbed by the sodium nitrate in the dynamite, that salt being highly hygroscopic. As soon as the sodium nitrate has deliquesced, that is, melted from absorption of moisture, the homogeneity of the dynamite becomes disturbed, and the "dope" fails to retain the nitroglycerine, which then leaks out. The watery substance often seen on cartridge-paper, and the oily stain seen in dynamite boxes, is due to the leaking of the nitroglycerine. A cartridge in this condition is far more liable to accidental explosion than sound dynamite, and it is perilous and uneconomical in use. It will not develop the same energy as good dynamite; it is likely to burn and blow out instead of detonating properly; and it is a frequent cause of "misfires," and of the failure of a charge to explode to the bottom of a hole. —*Mining and Scientifi Press. c*

To ward off the evil of gas leakage, concrete curbing 5 ft. deep has been built around the new parks in Chicago.

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

Established 1896

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ANOTHER VOLUME COMPLETED

The present issue completes another volume—the thirteenth—of our COMPRESSED AIR MAGAZINE, and gives occasion for a word as to what has been done, and especially as to the work ahead.

It is gratifying and stimulating to note that the use of compressed air as a means of power transmission, and for the multitudinous employments for which it is especially adapted, is rapidly and continually extending, and that every new job which it gets it holds, with no diminution in any of its already established activities. Compressed air apparatus is continually being developed and improved and added to, and those interested in it and seeking information concerning it are becoming more numerous.

Compressed air has won its way not always by undertaking in advance to do its work cheaper than any other agent, measured always by the power cost alone, but rather by its instant and constant readiness for action and its precise adaptability to certain lines of work, and these characteristics, which should recommend and advance any prospective worker, have led to appreciation and constantly widening employment. The extension of the uses of compressed air during the life of this magazine has been really quite astonishing. Not to go into details at all, those sufficiently informed will surely concede at least a tenfold increase in these thirteen years, the increase extending in every direction, the number of compressors, the number of air operated apparatus, the number of distinct and specific operations, and necessarily also a similar increase in the number of firms and individuals using it and seeking, or welcoming when not sought, newer and fuller knowledge which will still further extend the field of its activities.

It is to be remembered that the indefiniteness of the term "compressed air" makes it all-comprehensive. All air of which we can have any knowledge is compressed air. "Free" air, at whatever altitude, is always compressed by all that is above it, so that in treating of compressed air and its relations with things in general we necessarily have to do, as our sub-title suggests, with "everything pneumatic." No periodical of a technical character within our knowledge has so wide a reach of interests to cater to as ours, and if we have failed, as we have and must, to adequately serve them all, we may at least hope and resolve to have a wider and a widening influence in the future.

What success we may have must depend largely upon our readers. With a field so entirely and exclusively our own, with no other periodical in the world in competition, with so vast and diverse interests to cater to, our position is really unique in the technical press. What subscribers and readers and advertisers we have have come to us practically unsolicited, in which particular we have no doubt been remiss. Our record is deplorably unique. While advocating so constantly the use of compressed air we have employed none of it for the blowing of our own horn.

THE A. S. M. E. RELEASES ITS PAPERS FOR ADVANCE PUBLICATION

Editor Compressed Air:

We are pleased to announce that the Society has determined to release the papers to be presented at its meetings for general publication in the technical magazines, immediately after such papers appear in The Journal. The former rule has been against allowing them to be published, even in abstract, until after they were presented at a meeting. The Society is anxious to facilitate, further, the reprinting of papers published in The Journal and discussions upon them contributed at the meetings, and, upon request, will furnish, at cost, verbatim reports including the discussions of papers presented.

The American Society of Mechanical Engineers,
LESTER G. FRENCH, Editor.

NEW BOOKS

American Machinist Handbook and Dictionary of Shop Terms, by Fred H. Colvin and Frank A. Stanley, Hill Publishing Company, New York, 544 pages 4¼ by 6⅞ inches, bible paper, full gilt, limp leather cover, price $3.00. This book, prepared by two graduates of the shop, is packed full of tables, rules, formulas, data and general information, much of it new and all in readily usable condition, for machinists and workers in all the allied trades, for draftsmen and engineers, and represents in its preparation a vast amount of honest, skillful work dominated by exacting judgment. The dictionary portion is quite encyclopedic in character.

A Pocket-Book of Mechanical Engineering, by Charles M. Sames, Third Edition Revised and Enlarged, Jersey City, N. J., Charles M. Sames. 195 pages, 4¼ by 6¾ inches, ⅜ inch thick. Price $2.00. This is in fact as well as in name a pocketbook, and can be carried constantly without a suggestion of inconvenience. It is quite probable that so much in the way of tables, formulas, data, theory and examples was never before got into the same space. The book has a very satisfactory index.

How to Build up Furnace Efficiency, by Jos. W. Hays, Combustion Engineer, Jos. W. Hays, 601 Hartford Building, Chicago, 48 pages, 3½ by 6¼ inches. Price 50 cents. "There are dollars to be saved at the furnace from the book that the way to save dollars and only dimes at the engine," and we gather from this book that the way to save the dollars is to persistently use a "gas analysis instrument."

TRADE PUBLICATIONS

Catalogue Number 5, American Spiral Pipe Works, Chicago, 80 pages, 8 by 10¼ inches. This catalogue gives full information, with dimensions and price lists, of Spiral Riveted Pipe, Forged Steel Pipe Connections, Exhaust Steam and Hydraulic Supplies. Many photos and blue-print profiles and maps are given of long water supply lines, both for municipal service and power transmission. Various useful tables also are included.

Riveters, Catalogue No. 3, Hanna Engineering Works, Chicago, 64 pages and cover 6 x 9 inches. The riveters described have a movement giving the large opening of the toggle joint with increasing pressure in the advance and a simple lever action through a considerable space under approximately maximum pressure, thus producing hydraulic results with a pneumatic riveter. Many styles, sizes and applications of the riveters are shown. Hydro-Pneumatic Riveters also are described, and various other manufactures of the firm.

AIR TOOLS IN THE BOILER SHOP

Editor the Boiler Maker:

In all up-to-date boiler shops various kinds of air tools are being used: the air hammer for riveting, calking, chipping, etc.; the motor for drilling, tapping and countersinking and the jam hammer for bucking up rivets on mud rings and air drums. Air tools are also extremely useful in flue work, as they can be used for rolling, balling over, beading, etc.; but, of course, judgment must be used when using them for such work, as there is danger of overworking the flues, whereas the hand is very sensitive, and tubes can be set by hand without any danger of injuring the tube. Care must be used not to roll the flues too much, just the same as when driving rivets, the proper length must be chosen to give a good, full head.

Large air clamps for flanging are also a handy device for forming flue sheets, etc., as the hot sheet can be quickly clamped and then pounded into shape with heavy mauls. The furnace for heating the sheet can be run by oil and air, and with such a furnace the sheet can be heated evenly all over in one heat, and thus a vast amount of time and trouble saved. Also in reaming out, tapping and running in staybolts an air motor saves a vast amount of time. In fact, there is scarcely an air tool built for use in a boiler shop which is not a time saver.

HARRY JEWELL.

COMPRESSED AIR HYGIENE

(*Continued from Page* 5109.)

Practical experience of work in compressed air shows that even with very rapid decompression no symptoms of caisson disease occur with an absolute pressure of less than two atmospheres, and that symptoms are very rare and slight until the pressure rises beyond 2.3 atmospheres, or 19 lb. gage. This was found to be true also for goats. Now, if it is possible to decompress rapidly and with safety from two atmospheres, or a little more, to one atmosphere, it seemed likely that it would be possible to decompress with equal safety from four atmospheres to two, or from six to three, since the volume of gas tending to be liberated would be the same in each case. Experiment showed that this was the case, and that the danger of rapid decompression depends, not on the absolute difference between the initial and final pressure, but on the proportion between the two pressures. If this proportion is only 2, or 2.3 to 1 the decompression is safe; if, on the other hand, the proportion is 3 or 4 to 1, the decompression is dangerous.

The method hitherto recommended for bringing men safely out of compressed air has been to decompress at a slow and uniform rate. But calculation on the principle already referred to shows that, however slow this uniform decompression may be, the difference in partial pressure between the nitrogen dissolved in the tissues and the external air-pressure will go on increasing during the decompression. Still more will the proportional difference between two pressures increase. At the end of the decompression, therefore, the danger, if any, will be at a maximum, whereas during the first half, or more, of decompression time is simply being wasted, or much worse than wasted, if saturation of the body has been incomplete. All experiments confirmed this theoretical deduction.

STAGE DECOMPRESSION.

These considerations led to a new method, that of decompression in graduated stages. The principle of this method is that the worker in compressed air is brought rapidly to half the absolute pressure (or a little further if his tissues are not saturated), stopped there for a time, then decompressed a little further after sufficient time has elapsed to allow the maximum nitrogen pressure in any part of his body to become not more than twice the nitrogen pressure of the air at the lower stage. He is then brought on by further stages on the same principle until he reaches atmospheric pressure. For the difference between the stages a pressure of 0.3 atmospheres was selected, corresponding to 10 ft. of sea-water. The proper stoppages, after stays at different depths, and for different periods of time, have been carefully calculated and put into the form of a table, which is now in use in the Biritish Navy. This diving table extends to depths up to 204 ft.

For ordinary diving work the table limits the stay on the bottom in such a way that the diver can come up safely within half an hour. This is desirable for many reasons. After prolonged stays on the bottom at great depths the time required for safe decompression, even by the stage method, is far too long; and with uniform decompression many hours would certainly be needed at the greatest depths.

The method of stage-decompression was very thoroughly tested on goats, and compared with the old method of uniform decompression. The result was to show beyond all question that the stage-decompression method is greatly superior, particularly for diving work. Even when the rate of decompression was much too fast by either method, stage-decompression proved considerably safer. With goats it was necessary to provide for parts of the body taking as much as 45 minutes to become half-saturated or half-desaturated after a given alteration of pressure. For man we therefore consider it necessary to provide for parts requiring 75 minutes, as the respiratory exchange per unit of body weight in man is three-fifths that of goats.

In the case of caisson and tunnel work, the conditions are somewhat different from those in diving. In the first place, the pressures are not so high, while the period of exposure is usually longer—seldom less than three hours in the case of ordinary workmen. In the second place, there is not the same need for limiting the time spent during decompression, and therefore also limiting the period of exposure. Another important difference is that the occasional occurrence of symptoms in the air-lock is not a matter of such importance as in the case of a diver under water. The man in the air-lock has others to look after him, and he can be promptly relieved by raising the pressure. The occurrences of symptoms after he leaves the lock seems to be a matter of more moment, as it might be some time before he could be re-compressed, and he might have no one to help him.

Bearing in mind these circumstances, it seems desirable to adopt a somewhat slower rate of decompression in the case of caisson workers than in the case of divers who have been equally long exposed, and to make the decompression more gradual towards the end, so as to avoid any risky state of super-saturation in the body of a man after leaving the air-lock. The slow part of the stage-decompression then becomes theoretically very nearly uniform, so that a uniform rate may well be adopted. This considerably simplifies the carrying out of the slow part of the decompression, and the directions for the whole process.

The initial rapid stage would be to half the absolute pressure, and no slow stage at all would be needed if the pressure in the caisson did not exceed about 2.2 atmospheres in absolute measure, or 17½ lb. of excess pressure, since practical experience seems to show clearly that it is safe to decompress in three minutes from 17½-lb. pressure, or a little more. One or two exceptional cases where symptoms have occurred, though not of a serious nature, are, however, on record.

In order to avoid any chances of mechanical injury to the ears, and to keep within limits tested by practical reference, not less than two or three minutes should be allowed for the rapid decompression, and the outlet tap should be so regulated as to prevent a faster rate. If two or three minutes in all were taken the rate of fall of pressure would, however, naturally be much faster at the beginning than the end of the process, which would be an advantage. An accurate and easily read pressure gauge in the lock is, of course, essential, and it would also be desirable to have a graphic record of each decompression. The accompanying table shows the number of minutes to be allowed for each pound of decompression after the first rapid stage has been completed in 3 minutes. It has been taken into account that men will usually come out for meals after periods of about three hours work, and that, since they will not have time to desaturate during the interval, they will be more highly saturated after a second or a third period of work than after a first.

RATE OF DECOMPRESSION PER POUND.

Gage Pressure.	A.	B	C
18-20	2	3	5
21-24	3	5	7
25-29	5	7	8
30-34	6	7	9
35-39	7	8	9
40-45	7	8	9

A—After first 3 hours exposure.

B—After second or third 3 hours exposure, showing an interval for a meal.

C—After 6 hours or more of continuous exposure.

To illustrate the use of the table, first suppose that the pressure in the caisson or tunnel is 23 lb. by gauge, corresponding to an absolute pressure of 38 lb. The pressure in the lock can be reduced in three minutes to 19 lb., corresponding to an excess pressure of 4 lb. by gauge. The pressure will then be allowed to fall to normal, either uniformly or by about a pound at a time, in 12 minutes, so that 14 minutes in all will be spent in the lock after the first spell of about three hours' work. After a second or third spell, 22 minutes will be needed. With a continuous exposure all day, 30 minutes would be needed.

It will be seen that at high pressures there would be a saving of time in the lock if the men remained continuously in the compressed air. The time in the lock is, however, in any case very long at the higher pressures. This seems inevitable if a reasonable standard of safety is to be reached; and the aim of the table is to give about the same safety for work at over 20-lb. pressure as exists at present with work at under 20 lbs. Such a standard can only be reached by giving the necessary time for decompression, and the rates of decompression hitherto usually adopted are unsafe, particularly if the decompression is uniform.

With such long times spent in an air-lock, ventilation becomes necessary, and in order to permit of this it would probably be convenient to have an outlet provided with an adjustable safety-valve, so that the pressure could be kept steady at any point in spite of the influx of air. The lock should be large enough for a whole shift, and should contain an electric heater and telephone.

In order to avoid the tedious and prolonged stays in a small air-lock, it would probably be convenient in many cases to arrange for a roomy air-lock, or section of tunnel, kept at a constant pressure of 1-2.2 of the absolute pressure in the working space, with two small locks for passage to the working space, and to the outside. The men could be detained in this "purgatory" airlock for the necessary time, and then proceed rapidly through the small lock to the outside. By this plan no lock would be blocked for more than three minutes at a time, and if the men could wash, change, and take meals in the "purgatory" lock a great saving of time would be effected. If, for example, the working pressure were 30 lb., the "purgatory" lock could be kept at 5½ lb., and the men would need to stay in it about 50 minutes on their way out.

ALIVE IN CAPSIZED VESSELS

We read in Pearsons' Weekly of the remarkable escape of a sailor near Newcastle, New South Wales. The barkentine Kate Tatham turned turtle in a gale, and one of the crew was shut up in her hold. The survivors, who had climbed on her keel as she heeled over, naturally took it for granted that he was drowned. What was their surprise therefore presently to hear faint knockings from beneath their feet, evidently made by their imprisoned comrade. Help was at hand, and a hole was cut through the ship's bottom, when the man was hauled out, little the worse for his terrible experience. He had, it appeared, been kept alive by the air which had been imprisoned in the hull when the vessel capsized and which, becoming compressed as the water rose, had eventually stopped its further encroachment. He had used a balk of floating timber to support himself. We may suppose that lively work was called for when the hole was opened, as the air must have blown out rapidly and the man might have been drowned after all by the water rushing in from below.

The man's imprisonment lasted for two hours, and in the cabled reports, the incident is characterized as unparalleled. This, however, is by no means correct. There are several cases on record of men having lived in similar circumstances in the hulks of capsized ships not hours only but days, the most remarkable authenticated instance being that of Capt. Engallandt of the Erndte, who was rescued alive after an entombment lasting altogether eleven days eighteen hours. During this period the derelict, drifting bottom uppermost, was sighted by the masters of several vessels, all of whom, however, passed nonchalantly by, none imagining for a moment that the semi-submerged and capsized hulk contained, shut up in its vitals, a living man. Eventually the Erndte drifted ashore near Danzig and Capt Engallandt was taken out alive, although greatly emaciated.

THE WET-BULB HYGROMETER

Various instruments, in addition to the chemical hygrometer, have been developed for measuring the hygrometeric state of the air. The devices are purely empirical in their methods and in the results attained. Thus the wet-bulb hygrometer consists simply of two thermometers, one of which registers the temperature of the air and the other registers a different temperature which is attained by the following process: The bulb of the thermometer is surrounded by lamp wick, which is connected to a small vessel containing water. The wick draws up moisture from the water and evaporation occurs from its surface into the air. The rapidity of evaporation depends upon the relative dryness of the air. The water in its evaporation absorbs its own heat of liquefaction from surrounding bodies and produces a distinct cooling effect on the bulb of the thermometer, similar to that of the refrigerating machine.

THE CHEAPNESS OF WATERWORKS ENGINEERING

There are now on the Croton watershed, which is depended upon exclusively for the present water supply of Manhattan and the Bronx, nine separate dams, with another under construction, which will have an aggregate storage capacity of 104 billion gallons. It is found that a large additional storage can be secured on the east branch of the Croton River, above the present Sodom or East Branch reservoir. The estimated cost of the work for dam and accessories is $3,250,000, while the additional storage provided would be 20 billion (20.000,000,000) gallons. The cost per gallon, therefore, would be about one-sixtieth of a cent ($0.0001625) and the reservoir presumably good for a hundred years.

ANTHRACITE AND BITUMINOUS COAL DISTRIBUTION.

Outside the 480 square miles of the well known anthracite region of Pennsylvania in the counties of Susquehanna, Lackawanna, Luzerne, Carbon, Schuylkill, Columbia, Northumberland, Dauphin and Sullivan, there is hardly any true anthracite found elsewhere in the United States. In two small areas in the Rocky Mountain region coal has been locally anthracited, but the production has never amounted to as much as 100.000 tons in any year. The bituminous and lignite fields, on the contrary, are scattered widely over the United States, including an area of 496.000 square miles, divided into the six provinces, the Eastern or Atlantic Coast, the Gulf or Southern States, Interior or Mississippi Valley, the Northern or Great Plains, the Rocky Mountain, and the Pacific Coast. Bituminous coal is thus produced in twenty-six states and territories, and forms by large odds the greater part of the total production.

NOTES

The common building brick is the most widely spread of all clay products, being reported from every state and territory. In 1907, 9,705,698,000 common brick, valued at $58,785,461, were produced in the United States.

Isaac Charles Johnson, said to have been the inventor of Portland cement, is still living at Gravesend, England, at the age of 98. At his birth George III was king, Jefferson was president and Napoleon was at his greatest. Johnson became an architect and a house of his building is still standing at Swanscourt in Kent. This was the occasion of the Portland cement invention or discovery.

There has been recently patented in the United States by a citizen of Roumania, a method of preserving live fish during long periods of transport or storage. The process consists in continuously drawing off water from the tank containing the live fish, bringing this water into intimate contact with ozone, thereby "regenerating" the water, returning this regenerated water to the tank, and maintaining the water in the tank at a low temperature so as to control the movements of the fish. The original water in the tank is supposed to be water in which the fish had their natural habitat when caught. In transportation the water in the fish tanks is drawn through an ozonating device in the end of the car and returned to the tanks by means of a small pump, thus keeping up a constant circulation of the water and cooling said water at the same time by means of ice.

A pipe a yard long holds as many pounds of water as the square of its diameter in inches, very nearly. Thus, a pipe 30 ft. long and 2 in. inside dia., will hold 2x2x10=40 lbs. of water.

Apply soapsuds with a small brush to joints or fittings in an air pressure system to find leaks. It makes no difference how small the leak may be it will at once show up by the foaming soap bubbles.

Experiments which have been made abroad indicate that the heat of the exhaust of a gas engine will produce 1.1 to 1.5 pound of steam per horsepower hour, or it would be sufficient to raise from 600 to 820 pounds of water from the freezing to the boiling point. Arrangements are being made looking to the utilization of this waste heat.

It is stated that it takes fully ten days of continuous working of the refrigerating machinery on board ship to reduce the temperature of a cargo of fresh fruit to the point at which it may be safely held, viz.: 36° to 38° F., because of the heat in the fruit itself. The internal heat of the fruit is rapidly removed in the pre-cooling systems now in use in America, and hence such precooled fruit can be shipped long distances without deterioration.

Gerald Stoney recently remarked before the British Association that there is as much power in steam from atmospheric pressure down to 27½ inches vacuum as there is from 150 pounds down to atmospheric pressure, and that the power of a non-condensing plant can be doubled by the addition of an exhaust steam turbine and condenser, and in cases where there is not a supply of cooling water improvements in cooling towers have made them cheap and efficient.

The expression 3 degrees K, means 3 degrees, centigrade, above absolute zero, the expression being derived from the name of Lord Kelvin, who first defined the zero of the absolute temperature scale. This temperature, equal to about—455 Fahr., was obtained by Professor Omer when liquifying helium. He kept helium at a temperature of 4.5 K for two hours, and finally evaporated the liquid under the pressure of about 1 centimetre of mercury, or close to absolute vacuum, when the temperature was estimated to be about 3 degrees K.

A grain elevator exploded recently at Richford, Vt., killing 15 workmen in the elevator and 2 women who were walking on the tracks near the building. The explosion is ascribed to accidental or spontaneous ignition of grain dust. The corrugated iron roof was blown off and portions of it were carried more than a quarter of a mile away from the building. Several freight cars near the elevator were broken up and overturned. The fire which followed completely destroyed the elevator and adjoining power-house, a flour warehouse and 75 freight cars.

Meteors prove that the air is still dense enough to make those little bodies incandescent through friction at a height of one hundred miles; but up to the present, man has succeeded in exploring the atmosphere to a height of only sixteen miles. The greatest authentic height attained by a human being is 35,000 feet. Kites have flown to a height of 21,100 feet, and an unmanned balloon, carrying recording instruments, has reached 85,000 feet—a little more than sixteen miles.—*Youth's Companion.*

In the Bakerloo, Hempstead and Piccadilly (London) "tubes" they have just ended a great rat exterminating job. In these underground railways the rats have been multiplying until the insulation of the electric wires and cables was all disappearing before their voracious appetites. As ammunition a thousand tubes of a special virus were judiciously distributed over night, the first effect of the virus being to create a demand for the upper air similar to that experienced by a victim of *mal de mer.* In the morning Trafalgar Square and the outsides of other stations were strewn with thousands of carcasses.

The pneumatic tube system in the service of the New York post office is being rapidly extended. Heretofore the connection with the general post office did not extend beyond station G at 51st street and Broadway. It has now been extended to 124th street west and 125th street east, with several intermediate stations. The extension just completed links Station P, in the new Custom House, the Wall street station, the general post office and all the West Side stations as far as 124th street, except four which will also soon be connected. The east and the west sides also are connected and the east side lines also will be extended to Harlem.

The total excavation on the Panama Canal for September was 3,158,886 cubic yards place measurement, against 3,252,506 cubic yards in the previous month and 1,515,212 cubic yards in September, 1907. There were 25 working days in September, against 26 working days in the previous month of August, while the rainfall for September was 9.72 inches against 11.93 in August. The average daily output for September, 1908, was 126, 355 cubic yards, against 125,096 cubic yards in the previous month and only 56,118 cubic yards in September, 1907. Of the September excavation 3,089, 851 cubic yards were removed from the canal prism, against 3,152,471 cubic yards in August and 1,481,307 cubic yards in September, 1907.

Total excavation since May 1, 1904, when the United States began this work, 50,506,317 cubic yards out of an estimated 142,000,000 cubic yards then to be excavated.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D C.

OCTOBER 6.

900,132. AUTOMATIC AIR-HOSE COUPLING. Nelson Toy, Weir, Kans.

900,275. FLUID - PRESSURE REGULATOR. Louis B. Fulton, Pittsburg, Pa.

900,355. HUMIDIFIER. Frank B. Comins, Sharon, Mass.

900,356. HUMIDIFIER. Frank B. Comins, Sharon, Mass.

900,418. VARIABLE-CAPACITY COMPRESSOR. Bruno V. Nordberg, Milwaukee, Wis.

900,498. PNEUMATIC TIRE. Horace W. Dover, Northampton, England.

900,504. WINDMILL. Richard G. Finch, Plainville, Kans.

900,516. APPARATUS FOR MANUFACTURING HYDROGEN GAS. Edmond Geisenberger, Liege, Belgium.

900,533. FLEXIBLE FLUID-JOINT. Charles G. Hawley, Chicago, Ill.

900,603. FLEXIBLE FLUID-JOINT. Edward E. Silk, Chicago, Ill.

900,610. PNEUMATIC PAD. Hortensius E. Stow, Windsor, N. Y.

900,614. VENTILATOR SYSTEM FOR RAILWAY CARRIAGES AND THE LIKE. Sergius Timochowitsch, Moscow, Russia.

900,632. PUMP FOR PNEUMATIC TIRES. Henry M. Williams, Vincennes, Ind.

900,639. AIR-BRAKE SYSTEM. Bert Aikman, Chicago, Ill.

OCTOBER 13.

900,752. CONTROLLING MEANS FOR AIR-BRAKES. George Macloskie, Schenectady, N. Y.

900,812. DENTAL BLOWER. Percy E. Williams, Savannah, Ga.

900,814. AIR-COMPRESSOR. Wylie G. Wilson, Denver, Colo.

900,888. PNEUMATIC TIRE. Arthur C. Rudland, Vancouver, British Columbia, Canada

900,914. VALVE MECHANISM FOR GLASS-BLOWING APPARATUS. Charles M. Clarke, Pittsburg, Pa.

900,950. TUNNELING-MACHINE. Olin S. Proctor, Denver, Colo.

900,951. TUNNELING-MACHINE. Olin S. Proctor, Denver, Colo.

900,988. PUMPING AND COMPRESSING APPARATUS FOR AERIFORM FLUIDS. Honore M. Domecq-Cazaux, Paris, France.

901-049. FLUID-PRESSURE DISTRIBUTER. Joseph B. Tuor, St. Paul, Minn.

901,068. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. James P. Caulfield, Baltimore, Md.

901,170. CONTINUOUS-DRAW VACUUM WINDOW-GLASS MACHINE. Harry D. Hershey, Latrobe, Pa.

901,258. ELASTIC-FLUID MOTOR. Victor Pingret, Rio Grande do Sul, Brazil.

901,273. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. Morris S. Wright, Worcester, Mass.

901,289. COUPLING FOR FLUID-PRESSURE CONDUITS. Peter Furtner, Rosenheim, Germany.

901,310. METHOD OF SUPPLYING ENERGY TO ENGINES. Edward T. Young, Boston, Mass.

2. An improved method of supplying energy to an engine which consists in compressing a body of non-combustible combustion-sustaining gas, preferably atmospheric air, in a chamber to a degree insufficient to ignite the fuel to be used, and heating by external means a sufficient amount of said combustion-sustaining gas to a temperature sufficient to accomplish the ignition of the fuel injected into it, and injecting such fuel into it, whereby said fuel will be ignited and burned, as described.

OCTOBER 20.

901,344. AIR-COMPRESSOR. Henry J. Horstmann, Fort Wayne, Ind.

901,361. MOLDING PROCESS. William F. M. McCarty, Pleasantville, N. Y.

1. The hereindescribed process which consists in continuously discharging molten metal, into a hermetically sealed mold, at or near the surface of the metal introduced, until said mold is filled and simultaneously withdrawing air from said mold.

901,392. ROTARY TUNNELING-MACHINE. Russel B. Sigafoos, Denver, Colo.

901,490. PNEUMATIC FEEDER FOR THRESHING-MACHINES. Cory W. Sellers, Beloit, Kan.

901,499. COMBINED MOTOR AND COMPRESSOR. Charles P. Tolman, New York, N. Y.

901,538. STRIKING-PIN FOR PISTON-HAMMER ROCK-DRILLING ENGINES. John G. Leyner, Denver, Colo.

901,539. MULTIPLE-STAGE AIR-COMPRESSOR. John G. Leyner, Denver, Colo.

901,550. FLUID-PRESSURE MOTOR. Eberhardt P. Nicholson, New York, N. Y.

901,555. AIR-COMPRESSOR. Thomas O. Perry, Chicago, Ill.

901,580. CONDENSING-APPARATUS PUMP. John Astrom, Milwaukee, Wis.

901,660. AIR SELF-COUPLING. Benjamin F. Sweeney, Neosho, Mo.

901,741. PRESSURE-REDUCER FOR GASEOUS LIQUIDS. Harry A. Reed, New York, N. Y.

901,923. AIR-BRAKE. James F. McElroy, Albany, N. Y.

OCTOBER 27.

901,945. AIR-PUMP. Phillips P. Bourne, Somerville, Mass.

902,001. AUTOMATIC REGULATING DEVICE FOR FLUID-PRESSURE APPARATUS. Auguste C. E. Rateau, Paris, France.

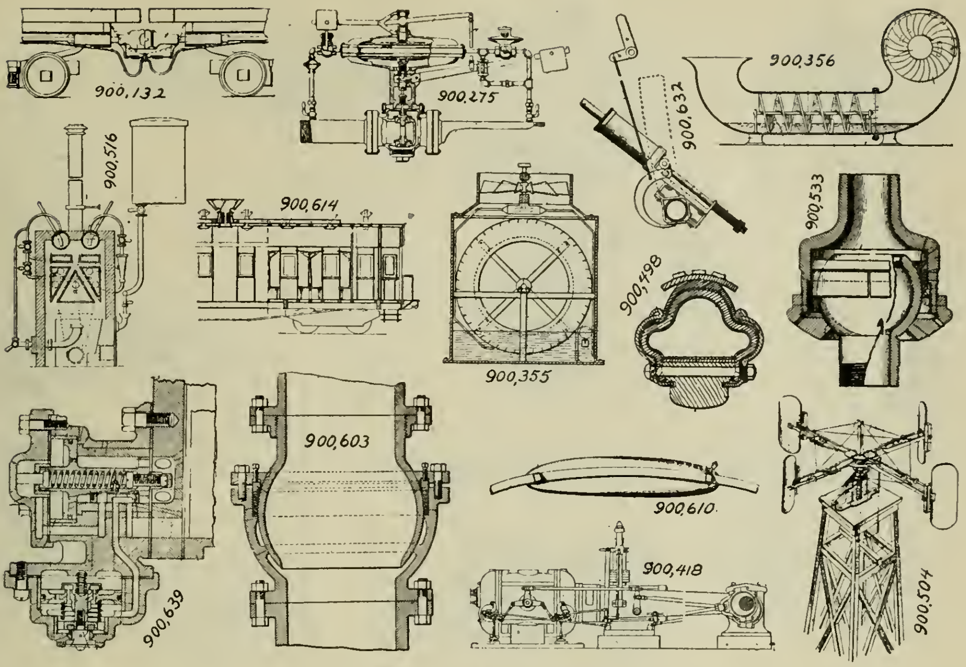
902,077. DEVICE FOR EXHAUSTING AIR FROM SIPHONS OF SLUICES AND THE LIKE. Christian Havestadt, Wilmersdorf, near Berlin, Germany.

902,114. FLUID-PRESSURE BRAKE SYSTEM. William H. Sauvage, New York, N. Y.

902,142. LOG-TURNER. Aage Foss and Loren Coolidge, Montesano, Wash.

902,182. HIGH-SPEED-REDUCING VALVE FOR AIR-BRAKES. Walter V. Turner, Wilkinsburg, Pa.

902,183. HIGH-SPEED-REDUCING VALVE FOR AIR-BRAKES. Walter V. Turner, Wilkinsburg, and John S. Custer, Pittsburg,



Pneumatic Patents, October 6.

Pa.

902,184. ELECTROPNEUMATIC BRAKE. Walter V. Turner, Wilkinsburg, Pa.

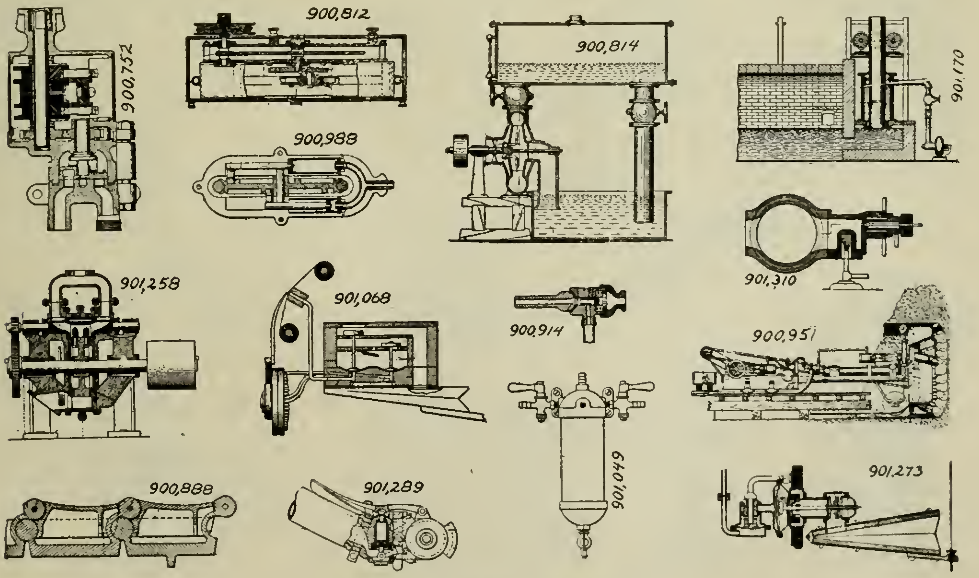
902,264. FLUID-CONTROLLING MEANS. Fred P. Stevens, Denver, Colo.

902,288. FLUID-PRESSURE-ENGINE-OPERATED TOOL. George H. Gilman, Claremont, N. H.

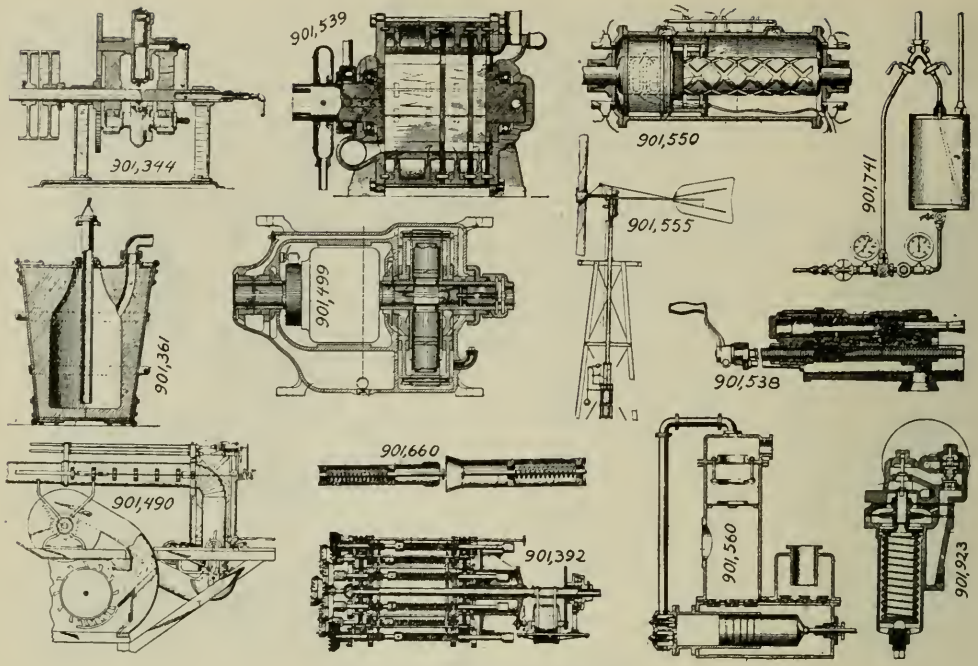
902,382. AUTOPNEUMATIC MOTOR FOR SELF-PLAYING MUSICAL INSTRUMENTS. John W. Darley, Jr., Baltimore, Md.

902,441. ROTARY BLOWER OR COMPRESSOR. Oscar P. Ostergren, New York, and Charles O. L. Cardell, Pearl River, N. Y.

902,501. PUMP, &C. Fritz W. Machlet, Elizabeth, N. J.

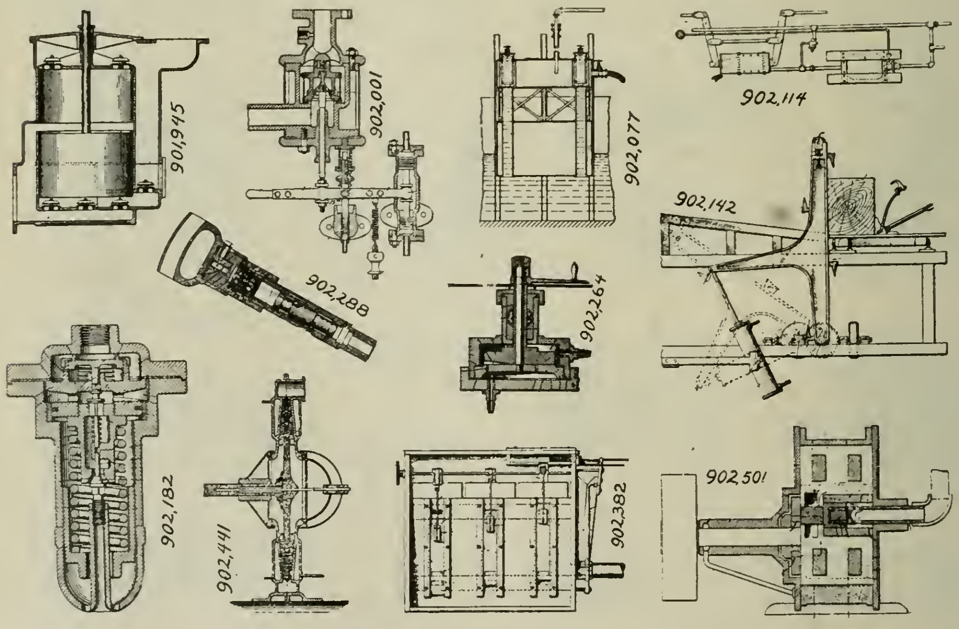


Pneumatic Patents, October 13.



Pneumatic Patents, October 20.

1. A rotary air or gas pump comprising a drum, a hollow cylinder revolving therein, a vane or piston sliding in and out of said cylinder and fitting to the interior of the drum, and means for conducting liquid from the cylinder to the edges of the vane to form a seal or packing for the latter.



Pneumatic Patents, October 27.

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Compressed air

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ENGINEERING

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